Preface

This set of materials is designed to be used as handouts accompanying an advanced course in phonology, particularly at the graduate level. It is specifically intended to be used in conjunction with two textbooks: *Phonology in generative grammar* (Kenstowicz 1994), and *Optimality theory* (Kager 1999). However, this course packet could potentially also be adapted for use with other phonology textbooks. The materials included here have been developed by myself and others over many years, in conjunction with courses in phonology taught at SIL programs in North Dakota, Oregon, Dallas, and Norman, OK. Most recently I have used them at GIAL. Many of the special phonetic characters appearing in these materials use IPA fonts available as freeware from the SIL International website.

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Dallas, 2018
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Practical premises for phonological analysis

The following is a compilation of practical guidelines which you should find helpful as you do phonological analysis. This list is from the book *Phonemics*, written by Kenneth L. Pike, although the numbering has been changed from the original and footnotes were added for clarification.

1. A phonemic orthography is the easiest one for the native to learn to read and write.
2. Phonemic procedures are based upon universal language characteristics.
3. Borders of major phonological and grammatical units can cause the nonsignificant modifications of sound units.
4. Stress, pitch, and length can affect or be affected by sound segments.
5. Sounds tend to become more like the environments which modify them.
6. Tonal systems, as well as segment relationships, tend to be somewhat symmetrical.
7. Nonsignificant fluctuation of sound should not be written in a phonemic orthography.
8. Each language contains characteristic sequences of sounds.
9. Every language has consonants and vowels.
10. Certain kinds of segments may be vowels in one language but consonants in another, and vice versa.
11. The dichotomy between vowel and consonant is not strictly an articulatory one but is in part based on distributional characteristics.
12. Phonetic syllables are determined by physical and/or acoustic criteria.
13. Phonemic syllables are in part determined by distributional criteria, including potential placement of stress, pitch, and length, and in part by the structural shape of morphemes.

---

1 non-phonemic


© 1947 Kenneth L. Pike. Used by permission from copyright holder (Judith Pike Schram) for use by GIAL. Permission granted on April 7, 2011. (Pike’s premises.pdf)
14. A sequence of two segments may in some languages constitute a single phonetically complex phoneme.

15. Occasionally a single segment may constitute a consonant and a vowel simultaneously.

16. Some segments may be nonsignificant transition sounds.

17. Segmental or suprasegmental elements which are predictable are nonphonemic.

18. If two segments are submembers of a single phoneme, the norm of the phoneme is that submember which is least limited in distribution and least modified by its environments.

19. In order to be considered submembers of a single phoneme, two segments must be (a) phonetically similar and (b) mutually exclusive as to the environments in which they occur.

20. Every phonetically distinct segment of a language is a separate phoneme unless it is part of some more inclusive phonemic unit.

21. When two phonemic conclusions each appear to be justifiable by the other premises, and each seems to account for all the available facts of all types, that conclusion is assumed to be correct (a) which is the least complex, and (b) which gives to suspicious data an analysis parallel with analogous nonsuspicious data, and (c) which appears most plausible in terms of alleged slurs into specific environments.

22. Two segments are proved phonemically distinct if they consistently constitute the only difference between two words of different meanings.

23. The native speaker can more easily be taught to recognize and symbolize the difference between two of his phonemes than between two submembers of phonemes.

24. In some languages considerable grammatical analysis, based on phonetic data, is prerequisite to phonemic analysis since spaces and hyphens must be written at certain types of grammatical units, and subphonemic modifications may occur at their borders.

25. A PHONEME is one of the significant units of sound arrived at for a particular language by the analytical procedures developed from the basic premises previously presented.

---

2 allophones
3 underlying form
4 allophones

AL 5304, Advanced Phonological Analysis, GIAL, Day 1
(source: Jim Roberts)

PHONEMICS – ANALYTICAL PROCEDURES

- make phonetic chart of data
  - identify suspicious pair(s)
    - identify phonetic differences between segments
      - examine environments in which each occurs
        - environments identical
          - never makes a difference in meaning
        - environments very similar
          - makes a difference in meaning
            - define differences in environments
              - make hypothesis as to environment in which each occurs
                - check data to try to refute hypothesis
                  - counterexample(s) found
                    - hypothesis can’t be refuted – no counterexamples
        - environments different
          - define differences in environments
            - make hypothesis as to environment in which each occurs
              - check data to try to refute hypothesis
                - counterexample(s) found
                  - hypothesis can’t be refuted – no counterexamples

FREE VARIATION

- variation in every environment
  - unconditioned
    - free variation
      - write a rule (optional rule) which has no environment
- variation in only some environments
  - conditioned
    - free variation
      - write a rule (optional rule) with relevant environment

CIE

CONTRAST – separate phonemes
(phonetic differences are not predictable) – no rule can be written

COMPLEMENTARY DISTRIBUTION

- one phoneme (phonetic differences are predictable, caused by environment)
  - decide on underlying form of the phoneme
    - write a rule (obligatory rule) to show predictability of occurrence of allophones
Classical Distinctive Features

|       | p | pʰ | pʼ | b | t | d | k | g | ŋ | β | f | v | θ | ð | s | z | ŋ | ž | x | θ | t⁸ | d⁹ | č | ĵ |
| syllabic       | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| consonantal    | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| sonorant       | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| continuant      | - | - | - | - | - | - | - | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| delayed release | - | - | - | - | - | - | - | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| strident       | - | - | - | - | - | - | - | - | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| distributed    | + | + | + | + | - | - | - | - | + | + | - | - | + | + | - | - | + | + | - | - | + | + | + | + | + |
| lateral        | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| anterior       | + | + | + | + | + | - | - | + | + | + | + | + | + | + | - | - | + | + | - | - | + | + | - | - | - |
| coronal        | - | - | - | - | + | + | - | - | - | - | - | - | - | + | + | + | + | - | - | + | + | + | + | + | + |
| nasal          | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| voice          | - | - | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | - | + | + | + | + |
| aspirated      | - | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| glottal        | - | - | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| high           | - | - | - | - | - | + | + | - | - | - | - | - | - | - | - | - | - | - | + | + | + | - | - | + | + |
| low            | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| back           | - | - | - | - | - | + | + | - | - | - | - | - | - | - | - | - | - | - | + | - | + | - | - | - | - |
| round          | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| ATR (tense)    | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

ϕ = p  β = b  δ = d  ŭ = ũ  ž = ź  γ = g  t⁸ = c = č  ċ = t⁹ = tʃ  ʃ = d⁹ = dʒ
### Classical Distinctive Features

|          | m | n | ñ | l | ñ | y | w | ñ | h | i | ñ | e | ñ | a | i/i | u | o | o | c |
| syllabic | – | – | – | – | – | – | – | – | – | – | + | + | + | + | + | + | + | + | + |
| consonantal | + | + | + | + | + | + | + | – | – | – | – | – | – | – | – | – | – | – | – |
| sonorant | + | + | + | + | + | + | + | ± | ± | ± | + | + | + | + | + | + | + | + | + |
| continuant | – | – | – | – | – | ± | + | + | + | – | + | + | + | + | + | + | + | + | + |
| delayed release | – | – | – | – | – | ± | + | + | + | + | – | + | + | + | + | + | + | + | + |
| strident | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| distributed | + | – | – | + | – | – | – | – | – | – | + | – | – | – | – | – | – | – | – |
| lateral | – | – | – | – | – | + | + | – | – | – | – | – | – | – | – | – | – | – | – |
| anterior | + | + | + | – | – | + | + | – | – | – | – | – | – | – | – | – | – | – | – |
| coronal | – | – | + | + | – | + | + | – | – | – | – | – | – | – | – | – | – | – | – |
| nasal | + | + | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| voice | + | + | + | + | – | + | + | + | – | – | + | + | + | + | + | + | + | + | + |
| aspirated | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| glottal | – | – | – | – | – | – | – | – | – | – | + | + | – | – | – | – | – | – | – |
| high | – | – | – | + | – | – | – | + | – | – | + | + | – | – | – | – | – | – | + | + | – | – |
| low | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | + | – | – | – | – | – |
| back | – | – | – | – | + | – | – | – | – | – | – | – | – | – | + | + | + | + | + | + | + |
| round | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | – | + | + | + | + |
| ATR (tense) | – | – | – | – | – | – | – | – | – | – | + | + | – | ± | + | – | – | + | – | – | – |

\[ \tilde{e} = \tilde{a} \quad y = y \quad \hat{i} = \hat{i} \quad \hat{i} = \hat{u} \]

Note that \([i]\) is phonetically central and \([\hat{i}]\) is phonetically back.
**Major Class Features**

<table>
<thead>
<tr>
<th>syllabic →</th>
<th>syllabic ←</th>
</tr>
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<tbody>
<tr>
<td><strong>obstruents</strong></td>
<td><strong>nasals</strong></td>
</tr>
<tr>
<td>stops</td>
<td>laterals</td>
</tr>
<tr>
<td>fricatives</td>
<td>rhotics</td>
</tr>
<tr>
<td>affricates</td>
<td>syllabic nasals and liquids</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>sonorant</th>
<th>consonantal</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+</td>
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<tr>
<td>−</td>
<td>−</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>glides (laryngeal glides)</th>
<th>vowels</th>
</tr>
</thead>
</table>

↓

↑
Classical generative distinctive features for vowels

<table>
<thead>
<tr>
<th></th>
<th>–back</th>
<th>+back</th>
<th>–round</th>
<th>+round</th>
<th>–round</th>
<th>+round</th>
</tr>
</thead>
<tbody>
<tr>
<td>+high</td>
<td>+ATR</td>
<td>i</td>
<td>ü</td>
<td>û̈</td>
<td>u̇</td>
<td>u̇</td>
</tr>
<tr>
<td>–low</td>
<td>–ATR</td>
<td>ɪ</td>
<td>ı̈</td>
<td>ʌ̈</td>
<td>ʊ̈</td>
<td>ʊ̈</td>
</tr>
<tr>
<td>–high</td>
<td>+ATR</td>
<td>e</td>
<td>ö̈</td>
<td>ʊ̈</td>
<td>ȯ</td>
<td>ȯ</td>
</tr>
<tr>
<td>–low</td>
<td>–ATR</td>
<td>ɛ̇</td>
<td>ʌ̈</td>
<td>ʌ̈</td>
<td>ʌ̈</td>
<td>ʌ̈</td>
</tr>
<tr>
<td>+low</td>
<td>+ATR</td>
<td>æ̈</td>
<td>ȧ</td>
<td>ȧ</td>
<td>ȧ</td>
<td>ȧ</td>
</tr>
<tr>
<td>–low</td>
<td>–ATR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ü = y  i̯ = u̯  ı̈ = Y  ö̈ = ø
C, V

These cover symbols refer to the classification of segments as consonants and vowels, respectively. In terms of distinctive features, they correspond most closely to the classes defined by [–syllabic] and [+syllabic] (leaving aside the issue of syllabic consonants). They may not technically be needed in the formulation of every rule, but are often put in by convention for ease in reading the rules. Note that C is not the equivalent of [+consonantal], nor does V stand for [–consonantal].

Subscripts and superscripts

A number subscripted underneath a symbol indicates the minimum number of occurrences of that item which are necessary; similarly, a superscript indicates the maximum number of occurrences:

\[ C^3_i \text{ - means at least one consonant, but not more than three consonants, i.e., C or CC or CCC.} \]

\[ C_0 \text{ - this is often used in rules such as stress rules where the number of intervening consonants in a given position is irrelevant; this symbol simply means any number (zero or more) of consonants, with no upper limit.} \]

\[ V \rightarrow [+stress] / \_\_ C_0 V C_0 \# \]

Note that the symbol \( \hat{V} \) can be used for a stressed vowel:

\[ V \rightarrow \hat{V} / \_\_ C_0 V C_0 \# \]

Null symbol (Ø)

This symbol, which indicates the null set or “zero,” is also used in certain phonological rules. It may appear either in the input or output position of a rule as a placeholder in cases of insertion or deletion of segments:

Insertion: \( \ vitium \rightarrow i / C \_\_ C \# \)

Deletion: \( C \rightarrow \Ø / V \_\_ \# \)

\[ [+nas] \quad [+long] \]
Parentheses ()

Items placed within parentheses may be optionally present, but are not required to be. The use of parentheses in the environment of a rule allows us to collapse together more than one rule when these are obviously related to each other:

\[
C \rightarrow \begin{cases} 
+\text{high} \\
-\text{back} 
\end{cases} / \ _\ _\ (C) \quad V \\
\begin{cases} 
+\text{high} \\
-\text{back} 
\end{cases}
\]

This rule combines the following two rules:

\[
C \rightarrow \begin{cases} 
+\text{high} \\
-\text{back} 
\end{cases} / \ _\ _\ C \quad V \\
\begin{cases} 
+\text{high} \\
-\text{back} 
\end{cases}
\]

and

\[
C \rightarrow \begin{cases} 
+\text{high} \\
-\text{back} 
\end{cases} / \ _\ _\ V \\
\begin{cases} 
+\text{high} \\
-\text{back} 
\end{cases}
\]

Note that parentheses can also be used, in some cases, instead of superscripted and subscripted numbers. For example,

\[
(C) = C^1_0 \\
C(C) = C^2_1 \\
C(C)(C) = C^3_1 \\
or \\
C(C(C))
\]

Curly braces {}

This device allows us to indicate an either-or choice between the items enclosed within the brace. These are only to be used when the individual items are completely distinct and cannot be collapsed together by other means:

Correct: \[ C \rightarrow \emptyset / \ _\ _\ \left\{ C \right\} \]

Incorrect: \[ s \rightarrow [+\text{high}] / \ _\ _\ \left\{ i \right\} \]

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(In the incorrect rule above, the [i] and the [e] should be combined together as a natural class with a feature such as [–back].)

Transformational rules

Transformational rules in phonology are used to effect more than one change within a single rule. This type of rule is only used when a single process involves an effect on more than one segment. The most common examples are cases of metathesis, whereby two segments are interchanged (inverted in their linear order), and coalescence, whereby two underlying segments combine to become one phonetic segment that typically has characteristics of both of the original segments:

Metathesis: $C \quad ?$
\[\begin{array}{c}
\phantom{1} 2 \\
[+\text{son}]
\end{array}\]
\[\begin{array}{c}
1 \quad 2 \\
\Rightarrow \\
2 \quad 1
\end{array}\]

Coalescence: $V \quad C$
\[\begin{array}{c}
\phantom{1} 2 \\
[+\text{nas}] \quad \#
\end{array}\]
\[\begin{array}{c}
1 \quad 2 \quad 3 \\
\Rightarrow \\
1 \quad \emptyset \quad 3
\end{array}\]
\[\begin{array}{c}
\phantom{1} \\
[+\text{nas}]
\end{array}\]

In each case, the input and the environment (when necessary) are put together in a linear string. The numbers are placed underneath in order to index each element (segment and/or boundary symbol). As usual, the output of the rule only indicates the relevant changes to the string: any changes to a segment are placed below the number that indexes that segment. A change in the order of the segments (as in metathesis) is indicated by the order of the indexing numbers in the output (to the right of the arrow).

Variables ($\alpha \beta$)

Consider a language which has a voicing assimilation process, whereby an obstruent takes on the same voicing as the consonant which follows it. This process could be expressed by the following two rules:

\[C \rightarrow [+\text{voice}] / \_ \_ C\]
\[\begin{array}{c}
[-\text{son}] \\
\end{array}\]

\[C \rightarrow [-\text{voice}] / \_ \_ C\]
\[\begin{array}{c}
[-\text{son}] \\
\end{array}\]

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However, because of the similarity of these two rules, and because we would like to claim that these two cases are really just different instances of the same process, we would like to collapse the two into one rule. We do this by means of variables, symbolized by the Greek letters \( \alpha, \beta, \gamma, \) etc. Variables of this sort may take on the usual values + or – that are associated with features. Thus we can collapse the two rules above as follows:

\[
\begin{align*}
C & \rightarrow [\alpha \text{ voice}] / \quad C \\
[\text{–son}] & \quad [\alpha \text{ voice}]
\end{align*}
\]

In other words, if the second consonant is [+voice], then the preceding obstruent will also be [+voice]; if the second consonant is [–voice], then the preceding obstruent is also [–voice].

A process of nasal assimilation can also make use of this sort of variable. Consider the case where a nasal consonant takes on the same point of articulation as a following consonant. Using variables with the relevant distinctive features, this could be expressed as:

\[
\begin{align*}
C & \rightarrow \begin{bmatrix}
[\alpha \text{ ant}]
\beta \text{ cor}
\gamma \text{ high}
\delta \text{ low}
\varepsilon \text{ back}
\end{bmatrix} / \quad C \\
[\text{+nas}] & \quad \begin{bmatrix}
[\alpha \text{ ant}]
\beta \text{ cor}
\gamma \text{ high}
\delta \text{ low}
\varepsilon \text{ back}
\end{bmatrix}
\end{align*}
\]

This rule merely says that for the point of articulation features (anterior, coronal, high, low, and back), the nasal will take on the same values as a following consonant has for these same features. The following is a shorthand notation for the same rule:

\[
\begin{align*}
C & \rightarrow [\alpha \text{ place}] / \quad C \\
[\text{+nas}] & \quad [\alpha \text{ place}]
\end{align*}
\]

In this rule, the “feature” [place] is simply an abbreviation for the five features that refer to the point of articulation. Keep in mind that technically the rule with [\alpha \text{ place}] is really not simpler than the previous rule with five features; this notation is handy, however, and is often used to express this generalization in abbreviated fashion.

Another similar case is degemination, which can be expressed by a rule such as the following:

\[
\begin{align*}
C & \rightarrow \emptyset / \quad C \\
[\alpha \text{ FT}] & \quad [\alpha \text{ FT}]
\end{align*}
\]
Here the [FT] is an abbreviation for all the features used to describe a segment. The variable indicates that all features of the two consonants in the rule must have the same values, i.e., that the two are identical in every way. In such a case, we are told to delete the first one in our rule — in other words, to degeminate.

One caution should be made about using variable notation. Since the Greek letters are used for cross-referencing purposes (to say that the value of one feature is the same as something else), each variable must occur at least twice in a rule.

**Boundaries**

Sometimes a rule applies only if the segment occurs in a certain position in the syllable, word, or utterance. In early versions of generative phonology it was not considered proper to make reference to the notion of syllable. This is quite the opposite of most current theories. Reference to the edge of the syllable might be made as follows:

\[
A \rightarrow B \ / \ ___ \ ]_\sigma \quad \text{where} \quad ‘\sigma’ = \text{syllable} \quad \text{and} \quad ‘]’ = \text{right edge.}
\]

It has also been argued that phonological rules may make reference to the internal structure of the syllable. The following rule says that A becomes B if it is in the rhyme of the syllable:

\[
\begin{align*}
\text{rhyme} \\
A & \rightarrow B \\
\end{align*}
\]

The version of generative phonology that dominated the field for many years also explicitly allowed reference to morphological boundaries in rules. These boundaries are symbolized as follows:

\[
+ \quad \text{morpheme boundary} \\
\# \quad \text{single (interior) word boundary} \\
### \quad \text{double (exterior) word boundary} \\
\| \quad \text{utterance (or phonological phrase) boundary}
\]

Rules such as the following were commonly seen in the literature of the classical period:

\[
A \rightarrow B \ / \ ___ \ + \ Z
\]

\[
C \rightarrow D \ / \ X \ ___ \ #
\]
The power of such a theory was severely curtailed in some versions of lexical phonology, however. For example, Mohanan (1986) proposed that reference to such boundaries should be considered illicit, and that the only morphological boundary that a phonological rule may refer to is the bracketing itself. In his theory, each morpheme comes from the lexicon with bracketing of its own and the word formation rules provide more brackets, as shown below (using English spelling rather than phonological representations):

\[
\begin{array}{c}
[ [ [un] [happy]_{Adj} ]_{Adj} [ness] ]_{Noun}
\end{array}
\]

Therefore rules such as the ones given immediately above are not possible in this theory, whereas rules such as the following are allowed (where ‘]’ indicates the end of a morpheme and ‘[‘ the beginning of a morpheme):

\[
\begin{align*}
E & \rightarrow F / X \quad ] \\
G & \rightarrow H / \quad ] [ J
\end{align*}
\]

The original source for this handout is unknown.
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PHONETIC CHART OF VOWELS

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AL 5304, Advanced Phonological Analysis, GIAL  
Day 2

Some important resources for studying phonology

The Companion

UPSID
The UCLA Phonological Segment Inventory Database. An electronic sample of phoneme inventories from 451 random languages of the world. Available for free download:  
http://www.linguistics.ucla.edu/faciliti/sales/software.htm
See also the following summary description:  
http://en.wikipedia.org/wiki/UCLA_Phonological_Segment_Inventory_Database

Pbase
A database of several thousand sound patterns, including phoneme inventories, from 500+ languages. Compiled by Jeff Mielke for his dissertation. Available for free download:  
http://137.122.133.199/~Jeff/pbase/

WALS

Jennifer Smith’s homepage. Jen is a phonologist at the University of North Carolina. She and I were graduate students together at U.Mass. She has summaries and links to many helpful resources, especially in phonetics/phonology:  
http://www.unc.edu/~jlsmith/pht-url.html  
http://www.unc.edu/~jlsmith/ling-resources.html

Bruce Hayes’ homepage. He is a world-renowned phonologist who studied under Morris Halle at MIT. He also does computer programming, particularly related to phonology. See especially the section under Software for some very practical and helpful applications:  
http://www.linguistics.ucla.edu/people/hayes/

(resources for studying phonology.pdf)
Your homework for Day 5 consists of two parts:

1. In the Kenstowicz textbook, please read chapter 3, pages 89-114.

2. Turn in a write-up of the following two exercises (also from the textbook):

   (a) Exercise 2.4. Follow the instructions in the book. Also, state which of the two liquid allophones ([l] or [r]) you would posit (choose) as the underlying (phonemic) form, and why. Try to formalize the allophonic rule with the type of classical notation we have been using.

   (b) Exercise 2.6, sections A and B only (ignore section C). Follow the instructions in the book, formalize both of the rules, and demonstrate the correct ordering between them. Use the feature [+long] to indicate a lengthened segment. Also, note that the placement (location) of stress in these data is totally predictable. State in prose the rule (generalization) about which vowel/syllable receives the stress in each word. Don’t worry about formalizing the stress rule unless you really want to make an attempt to do so.

   (c) Exercise 2.9, to read only. You don’t need to write up or hand in anything on this problem.
Procedures for morphophonemic analysis

1. Make a pot of coffee.
2. Arrange the data into logical paradigms.
3. Make tentative morpheme cuts.
4. Identify those morphemes which exhibit more than one allomorph.
5. Identify the phonological differences between various allomorphs.
6. Group the alternating segments into logical natural classes.
7. Consider the phonological alternations from “both directions.”
8. Analyze the data to see which hypothesis yields the correct predictions.
9. Posit one unique underlying form for each morpheme.
10. Write formal rules which will derive all of the surface allomorphs.
11. Determine in what order the rules must apply to produce the correct results in all cases.
12. Write home to mom about how much you are enjoying linguistics.
Tips about rule application in derivations

After you find out what rules are necessary in a given language, and after refining them, determine whether the relative order in which they apply is important. If the rules are unordered, any sequence of application produces all the correct results. If the rules are ordered, one sequence of application produces all of the correct phonetic forms and another sequence will produce some incorrect results.

- Rules apply in a fixed order which must be discovered for every language.
- All rules are put in the list of rules, with crucial ordering indicated. Rules which are not critically ordered with respect to other rules are put last in the list.
- A derivation shows how all of the rules apply (or fail to apply) to a given word. This is true even in cases of free variation (optional rules). Optional rules are the same as any other phonological rules in the sense that they may be ordered or unordered.
- The first rule in the list applies directly to the underlying form; each subsequent rule applies to the output of the last rule which applied. The phonetic representation or surface form is equivalent to the output of the last rule that produced a change of any kind.
- You must attempt to apply every rule to every word. All rules must be shown in each derivation, regardless of whether they actually apply (produce a change) or not.
- If a rule does not apply to a word, this failure is indicated by a row of hyphens (-----).
- Crucial rule orderings must be demonstrated by one correct and one false derivation of the same word. This is most easily done when only two rules actually apply in the course of a derivation.
- An incorrect output (ungrammatical phonetic form) is indicated by a preceding asterisk (*[abcd]).
- One derivation is used for each word (e.g., each inflected form of each verb).
- All morphemes which compose a word are included in the underlying form (at the outset of the derivation). This means that no morphemes are added during the course of the derivation.
- Boundaries (morpheme, word, etc.) may be either (1) carried down through the derivation, or (2) written only in the underlying representation and made reference to when necessary.
- If a phonological rule assigns stress, then no stresses should be marked in underlying forms.

Example:

<table>
<thead>
<tr>
<th>Correct order</th>
<th>Incorrect order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underlying Form /xyz/</td>
<td>Underlying Form /xyz/</td>
</tr>
<tr>
<td>Rule A xz</td>
<td>Rule B -----</td>
</tr>
<tr>
<td>Rule B xp</td>
<td>Rule A xz</td>
</tr>
<tr>
<td>Phonetic Form [xp]</td>
<td>Phonetic Form *[xz]</td>
</tr>
</tbody>
</table>

1. ORGANIZE FORMS INTO PARADIGMS
   This will let you see alternations and their environments more clearly. It is not much good asking how to account for things until you know what to account for. (This step has been taken for you already in the problems you have been getting. In working on your own data it is a major part of the task. Many times the biggest obstacle to an insight being gotten is disorganization of the relevant data.)

2. MAKE MORPHEME CUTS
   Remember that all morpheme cuts are hypotheses, and you may need to change some of them. Remember that the boundaries are often obscured by phonological rules. Where the boundary is not immediately clear, mark (e.g. with colored pens) which parts clearly belong to one morpheme, which parts clearly belong to its neighbor, and which are questionable. Consider the following possibilities with respect to the questionable material:
   - It may belong totally to the first morpheme, or totally to the second.
   - It may belong to both morphemes, being formed by coalescence of the ending of the first morpheme and the beginning of the next.
   - It may belong to neither morpheme, being either epenthesized or belonging to a third morpheme whose presence you had not suspected.

3. LIST THE MORPHEMES YOU HAVE POSITED
   Take special note of those that alternate. Group those that show similar patterns of alternation together.

4. REARRANGE THE DATA
   Put side by side in the paradigm those forms in which morphemes are undergoing parallel alternations.

5. TAKE THE SIMPLE CASES FIRST
   Pick some pattern of allomorphy where the allomorphs are only slightly different and where it looks clear what the motivating environment is. When you hit difficult cases after doing a bunch of simple rules, go to step #17.

6. CHECK TO SEE IF THE ALTERNATION HAS ALREADY BEEN ACCOUNTED FOR
   Check any rules you have written previously to see if they account (or should be made to account) for the new alternation. For instance, if you have an alternation between voiced and
voiceless consonants and you already have a rule voicing certain consonants, see if the new alternation is not just a new case of the application of the earlier rule, or if it doesn’t show that the earlier rule was wrong and you really need to account for both the earlier data and these new data by a devoicing rule. In either case, make whatever adjustments are necessary and go back to step #5.

7. WRITE DOWN BOTH POSSIBILITIES
For instance, if you are looking at a pattern in which voiced consonants are alternating with voiceless ones, then either the voiced ones are devoicing, or else the voiceless ones are voicing (becoming \([+\text{voice}]\)). Write down the two possibilities on opposite sides of a sheet of paper and draw a line down the middle. Write the hypotheses each one entails (what you get in steps 8-13) on the appropriate half of the paper. For example:

\[
\text{C} \rightarrow [\text{--voice}] \quad | \quad \text{C} \rightarrow [+\text{voice}]
\]

8. WRITE DOWN THE INPUT FORMS
For each hypothesis, you will be positing that the input form will have what is to the left of the arrow rather than what is to the right. For instance, in the example given above, the two rules might be posited as alternative explanations for the alternations in the morphemes *kid*–*kit* ‘goat’ and *bæd*–*bæt* ‘evil’. The forms ending in \(d\) would be underlying in the devoicing hypothesis, and the forms ending in \(t\) would be underlying in the voicing hypothesis. The work sheet would thus look like this:

\[
\text{C} \rightarrow [\text{--voice}] \quad | \quad \text{C} \rightarrow [+\text{voice}]
\]

\[
\text{UR’s: kid} \quad \text{‘goat’} \quad \text{UR’s: kit} \quad \text{‘goat’}
\]

\[
\text{bæd} \quad \text{‘evil’} \quad \text{bæt} \quad \text{‘evil’}
\]

9. DETERMINE THE ENVIRONMENTS
Looking only at the forms which alternate, see what environment would make each one of the two rules work. Write down the rule with its environment. At this point your work sheet would look something like this:

\[
\text{C} \rightarrow [\text{--voice}] \quad | \quad \text{C} \rightarrow [+\text{voice}]
\]

\[
\text{UR’s: kid} \quad \text{‘goat’} \quad \text{UR’s: kit} \quad \text{‘goat’}
\]

\[
\text{bæd} \quad \text{‘evil’} \quad \text{bæt} \quad \text{‘evil’}
\]

\[
\text{C} \rightarrow [\text{--voice}] \quad | \quad \text{C} \rightarrow [+\text{voice}]
\]

\[
\text{UR’s: kid} \quad \text{‘goat’} \quad \text{UR’s: kit} \quad \text{‘goat’}
\]

\[
\text{bæd} \quad \text{‘evil’} \quad \text{bæt} \quad \text{‘evil’}
\]

\[
\text{C} \rightarrow [\text{--voice}] \quad | \quad \text{C} \rightarrow [+\text{voice}]
\]

\[
\text{UR’s: kid} \quad \text{‘goat’} \quad \text{UR’s: kit} \quad \text{‘goat’}
\]

\[
\text{bæd} \quad \text{‘evil’} \quad \text{bæt} \quad \text{‘evil’}
\]

10. ASK, “DOES IT WORK?”
Determine what kind of data would falsify each hypothesis. These will be cases in which the structural description of the rule is met but in which the change predicted by the rule has not taken place. This is easiest to check if there are non-alternating forms. For example, if the morpheme for ‘hat’ always occurs as \([\text{hæt}]\) regardless of whether it’s followed by a vowel or a consonant or a word boundary, this indicates that a voicing rule is not possible and that the UR’s of ‘goat’ and ‘evil’ end with voiced stops. If there are no non-alternating forms, check all other sequences that could falsify each rule. For example:

The devoicing rule above has as its structural description a syllable-final position. The
rule says that in all such situations the consonant should be voiceless. Therefore any voiced consonant in the environment $\sigma$ would falsify the rule. The voicing rule has as its structural description a VCV sequence. It predicts that in any such sequence the C should be voiced. Therefore any voiceless consonant in the environment $V \sigma V$ would falsify the rule. Always ask what the rule says should never occur. Whatever that is, try to find it in the data.

11. IF IT DOESN’T WORK, PATCH IT UP
If you succeed in falsifying a hypothesis, see what it takes to make it float. Consider the following possible ways of fixing up an ailing proposal:
   a. Modify the rule(s). Broaden or narrow the class of segments to which the rule can apply. Broaden or narrow the class(es) of segments in the environment.
   b. Change your morpheme cuts.
   c. Posit different underlying forms. Sometimes it may be necessary to break the morphemes into two groups in terms of UR’s. For example, if m and n alternate for two different morphemes, with m occurring before labials and n occurring before alveolars, this does not mean that the UR for each morpheme must be the same. It may be that the UR for one form contains m while the UR for the other form contains n.
   d. See if it might not be the case that interaction with some other rule(s) is causing the problem.
   e. If absolutely necessary, posit nonphonologically-characterized (suppletive) classes of morphemes which are either undergoing/not undergoing the rule, or conditioning/not conditioning it. See if the classes you posit can be characterized syntactically or semantically, or if they are the same classes needed by some other phonological rule. If they cannot be characterized in any such way, they are ad hoc classes. Posit these only as a last resort.

Keep going back to step #10, trying to falsify the rules, until you are pretty sure that they both work. Then go on to step #12.

12. JUDGE THE TWO HYPOTHESES
When both hypotheses finally work, judge them by the following criteria:
   a. Simplicity. Ceteris paribus (‘all other things being equal’) the simpler solution is better.
   b. Predictiveness. Ceteris paribus the solution that leaves unpredicted what could be predicted is not to be preferred. For instance, if, in some language, i (and no other vowel) alternates with $\emptyset$, and epenthesis and deletion solutions work equally well, the epenthesis solution would be preferable because it would explain (predict) why the vowel that alternates was always i, while that would be just an ad hoc fact in the deletion analysis.
   c. Naturalness. Ceteris paribus the solution that does what you expect languages to do is preferable. The more you learn about languages’ sound systems the better you will be able to apply this criterion.
   d. Adhocity. Ceteris paribus the solution needing less ad hoc machinery (e.g. morphemic classes, new types of formalisms) is preferable.
e. **Integration.** *Ceteris paribus* the solution that wreaks less havoc with the rest of your analysis is preferable.

If it actually makes things easier and/or more natural in the rest of your analysis, latch onto it!

Unfortunately, *ceteris* are rarely *paribus*. Often the more natural solution will mess up your analysis of other phenomena, or the simpler solution will be more ad hoc. You will have to weigh the different factors. The above criteria are more or less in order from weakest to strongest. Thus more weight should be given to integration than to simplicity, or to adhocity than to naturalness, etc.

13. **MAKE YOUR CHOICE, AND WRITE IT DOWN**
If a clear choice can be made, make it. Write down the reasoning behind it. Write down the crucial forms which show this hypothesis to be the correct one. If you cannot make a clear choice, write down the lines of reasoning for and against each hypothesis. In either case, note what predictions each hypothesis makes, so you can check them out against further data. Even after you are 95% certain that one solution is correct and the other wrong, it is wise to keep the rejected one in the corner of your mind. Further data just might show it to be right after all.

14. **MAKE SURE THAT THIS IS A SEPARATE PROCESS**
Check again to make sure that this new rule is not duplicating the work of a previously posited one. If it is, collapse the two rules into a single generalization.

15. **PEEL BACK THE EFFECTS OF THE RULE**
Go through the data undoing what was done by the rule you have just posited. For each form affected by the rule, write down the form you are positing as the input to the rule. Use those forms rather than the surface forms as the basis for further analysis. This will make it easier to see what the rules ordered earlier in the derivation are doing.

16. **GO BACK TO STEP #5**

17. **EXPLAIN COMPLEXITIES BY INTERACTION OF RULES**
When you have a case of complex allomorphy and/or a small set of forms which are stubbornly exceptional to well-motivated rules, see if you can’t account for the complexity through the interaction of several of the rules you have posited for simpler cases. You’ll be surprised how often you can. This is where the integration business (#12e) will show up best.

18. **MAKE SURE IT’S NOT A MISTEAK**
If you still can’t explain certain cases, go check with an informant to make sure the problem is not a transcriptional error or a slip of the tongue.

19. **KEEP TRACK OF RESIDUE**
If you still can’t account for a problem, chuck it into a corner marked RESIDUE and go back to step #5. Periodically review what you have in the Residue section and see if any new rules or analysis have any bearing on it. If you have analyzed everything else and are
left with residue, check to see if only one morpheme is involved. If so, account for the alternation via suppletion. Otherwise, either just leave it (plainly marked RESIDUE), or write a brute-force rule to get rid of it.

20. START OVER AGAIN
When you have accounted for all the alternations in your data, go elicit more data, and start over again at step #1.

(original source for this handout: © Rich Rhodes. Used with permission.)
### Lamba (spoken in Zambia and Zaire)

<table>
<thead>
<tr>
<th>Past</th>
<th>Passive</th>
<th>Applied</th>
<th>Reciprocal</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>čita</td>
<td>čitwa</td>
<td>čitila</td>
<td>čitana</td>
<td>‘do’</td>
</tr>
<tr>
<td>tula</td>
<td>tulwa</td>
<td>tulila</td>
<td>tulana</td>
<td>‘dig’</td>
</tr>
<tr>
<td>četa</td>
<td>četwa</td>
<td>četela</td>
<td>četana</td>
<td>‘spy’</td>
</tr>
<tr>
<td>soŋka</td>
<td>soŋkwa</td>
<td>soŋkela</td>
<td>soŋkana</td>
<td>‘pay tax’</td>
</tr>
<tr>
<td>pata</td>
<td>patwa</td>
<td>patila</td>
<td>patana</td>
<td>‘scold’</td>
</tr>
<tr>
<td>fisa</td>
<td>fiswa</td>
<td>fišila</td>
<td>fisana</td>
<td>‘hide’</td>
</tr>
<tr>
<td>česa</td>
<td>česwa</td>
<td>česela</td>
<td>česana</td>
<td>‘cut’</td>
</tr>
<tr>
<td>kosa</td>
<td>koswa</td>
<td>kosela</td>
<td>kosana</td>
<td>‘be strong’</td>
</tr>
<tr>
<td>lasa</td>
<td>laswa</td>
<td>lašila</td>
<td>lasana</td>
<td>‘wound’</td>
</tr>
<tr>
<td>masa</td>
<td>maswa</td>
<td>mašila</td>
<td>masana</td>
<td>‘plaster’</td>
</tr>
</tbody>
</table>

Sources of data:


Spanish rule ordering problem

Following are the paradigms of the three regular conjugations of the present tense, indicative mode verbs (some minor phonetic details have been omitted):

<table>
<thead>
<tr>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘speak’</td>
<td>‘eat’</td>
<td>‘live’</td>
<td></td>
</tr>
<tr>
<td>[áblo]</td>
<td>[kómo]</td>
<td>[bíbo]</td>
<td>first person singular</td>
</tr>
<tr>
<td>[áblas]</td>
<td>[kómes]</td>
<td>[bíbes]</td>
<td>second person singular</td>
</tr>
<tr>
<td>[ábla]</td>
<td>[kóme]</td>
<td>[bíbe]</td>
<td>third person singular</td>
</tr>
<tr>
<td>[ablámos]</td>
<td>[komémos]</td>
<td>[bibímos]</td>
<td>first person plural</td>
</tr>
<tr>
<td>[abláys]</td>
<td>[koméys]</td>
<td>[bibís]</td>
<td>second person plural</td>
</tr>
<tr>
<td>[áblan]</td>
<td>[kómen]</td>
<td>[biben]</td>
<td>third person plural</td>
</tr>
</tbody>
</table>

For the above surface forms, assume the following underlying representations:

<table>
<thead>
<tr>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>/abla + o/</td>
<td>/kome + o/</td>
<td>/bibi + o/</td>
<td></td>
</tr>
<tr>
<td>/abla + s/</td>
<td>/kome + s/</td>
<td>/bibi + s/</td>
<td></td>
</tr>
<tr>
<td>/abla</td>
<td>/kome</td>
<td>/bibi</td>
<td></td>
</tr>
<tr>
<td>/abla + mos/</td>
<td>/kome + mos/</td>
<td>/bibi + mos/</td>
<td></td>
</tr>
<tr>
<td>/abla + dis/</td>
<td>/kome + dis/</td>
<td>/bibi + dis/</td>
<td></td>
</tr>
<tr>
<td>/abla + n/</td>
<td>/kome + n/</td>
<td>/bibi + n/</td>
<td></td>
</tr>
</tbody>
</table>
In deriving the correct phonetic representations listed above, the following six rules need to be applied, in the order given:

(1) **Truncation:**  \( V \rightarrow \emptyset / \_\_ + V \)

(2) **d Deletion:**  \( d \rightarrow \emptyset / V + \_\_ V \)

(3) **Penultimate Stress:**  \( V \rightarrow [+\text{stress}] / \_\_ C_0 V C_0 \# \)

(4) **Gliding:**  \( i \rightarrow y / V \_\_ \)

(5) **Vowel Lowering:**  \( i \rightarrow e / V \_\_ C_0 \) [+stress]

(6) **Monophthongization:**  \( y \rightarrow \emptyset / i \_\_ \)

Instructions:

The written homework exercise which you are responsible for turning in on Day 6 consists of the following parts:

(A) Give a complete step-by-step derivation of all of the following surface forms, showing the application (or lack of application) of each of the six rules in turn to each form: [abláys], [kómo], [bibis], and [biben].

(B) Determine which pairs of rules are crucially ordered with each other. (I believe there are seven such pairs to be found. One of these is rather subtle, so if you discover six clear cases, you are doing pretty well.) List the names of the six rules in a vertical column and connect each pair of crucially ordered rules with an arc either on the left side or the right side. It is okay if some arcs cross over other arcs. Example:

```
Rule 1
Rule 2
Rule 3
Rule 4
Rule 5
```

e tc.

(C) After you have done step B (or as you are doing it), also state what type of relationship each pair of crucially ordered rules is in, following the guidelines discussed in class today. Remember the special condition which governs stress rules in particular. Note that the four specific words you are instructed to derive in part (A) above illustrate all seven of the crucial orderings you need to find in (B). In other words, deriving forms other than those four will probably not help you very much since you will not observe any other new interactions.
Rule Ordering Relationships

“When two (or more) rules are ordered, forms are affected differently by the various orderings. There are four crucial ordering relations — feeding, counterfeeding, bleeding, and counterbleeding. Ordering relations are determined by two interacting factors: (1) whether at the outset (before the derivation begins) both rules could potentially apply to a single form, and (2) whether in the course of the derivation both rules actually did apply to a single form.

Feeding order is where, given two rules \( a \) and \( b \), initially only one of them (let us say \( a \)) could apply; the rules are ordered so that \( a \) is first; it applies and the representation is then changed in some way such that \( b \) becomes applicable; hence the first rule \( a \) has fed (i.e. provided new inputs for) the second rule \( b \). Counterfeeding order is where \( b \) (which initially could not apply) is ordered first; of course nothing happens; \( a \) then applies.

Bleeding order is where, given two rules \( a \) and \( b \), both of them could apply initially to the same form; one of the rules (let us say \( a \)) applies first; the representation is changed in some way such that \( b \) cannot then apply; hence the first rule \( a \) has bled (i.e. removed inputs from) the second rule \( b \). Counterbleeding order is where \( b \) (which initially had the potential to apply) is ordered first; it of course now applies; \( a \) then applies next. Since both rules have applied the situation is counterbleeding. Note that counterbleeding is not the same thing as feeding even though both rules are able to apply in the course of the derivation. In counterbleeding situations both rules are able to apply from the outset, whereas in feeding only one of them is applicable initially and only after it has applied does the representation meet the conditions for the other rule.

The following chart summarizes the different ordering relationships:

<table>
<thead>
<tr>
<th>At the outset (right before rule ( a ) applies), could both rules potentially apply directly to (produce a change in) the same form?</th>
<th>In the observed derivation did both rules actually apply to (produce a change in) the same form?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes: potentially bleeding</td>
<td>Yes: counterbleeding (CB)</td>
</tr>
<tr>
<td>No: potentially feeding</td>
<td>Yes: feeding (F)</td>
</tr>
</tbody>
</table>

Ordered Rules

English

(a) Assibilation: \( t \rightarrow s \) / ___ + iy

(b) Coalescence: \( siy \rightarrow ĺ \) / ___ V
   [–stress]

‘presidency’: /prɛzədɛnt + iy/ \( \rightarrow \) [prɛzədensiy]

‘presidential’: /prɛzədɛnt + iy + æl/ \( \rightarrow \) [prɛzədensəl]

Swiss German

(a) Lowering: \( o \rightarrow ɔ \) / ___ C
   [+coronal]

(b) Umlaut: \( V \rightarrow [–back] \) / in plural forms

UR’s: /bodə/ /bogə/ (singular) /bodə/ /bogə/ (plural)
PR’s: [bɔdə] [bogə]

French

(a) Schwa Deletion: \( ə \rightarrow Ø \) / ___ #

(b) Final Consonant Deletion: \( C \rightarrow Ø \) / ___ # C

UR’s: /# pətit # garsə#/ /# pətit + ə # fiyə#/  
PR’s: [pəti garsə] [pətit fiy]

‘little boy’ ‘little girl’
Uruguayan Spanish

(a) Vowel Lowering: \( e \rightarrow \varepsilon \) / ___ C \{ C \} # { }

(b) Final \( s \) Deletion: \( s \rightarrow \emptyset \) / ___ #

UR’s: /# klase/# /# klase + s #/
PR’s: [klase] [klase] ‘class’ ‘classes’

Yawelmani

(a) Vowel Shortening: \( V \rightarrow [-long] \) / ___ C \{ C \} # { }

(b) Vowel Epenthesis: \( \emptyset \rightarrow i \) / C ___ C \{ C \} # { }

UR’s: /ʔa:ml + hin/ /ʔa:ml + al/
PR’s: [ʔa:milhin] [ʔamlal] ‘help’ (aorist) ‘help’ (dubitative)

Hungarian

(a) Backness Harmony: \( V \rightarrow [\alpha \text{ back}] \) / ___ V \{ C \} 0 + 0 ___

(b) CV Metathesis: C C V \{ # \} + CV \{ 1 \} 2 3 4 \rightarrow 1 3 2 4

UR’s: /poklo + t/ /poklo/ /poklo + nek/
PR’s: [poklot] [pokol] [pokolnak] ‘soot’ (accusative) ‘soot’ (nominative) ‘soot’ (dative)
Diegueño

(a) Lowering: \( \ddot{o} \rightarrow a / \_\_ \_ ? \)

(b) Schwa Epenthesis: \( \emptyset \rightarrow \ddot{o} / C \_\_ + C \)

UR’s: /p + č + tax/ /t + ? + am/
PR’s: [po̞čtax] [taʔam]
‘to be around’ (3rd plural) ‘to be around’ (1st singular)

-----------------------------

Hungarian

(a) Vocalization: w \( \rightarrow \) u / \_\_ \_ \{ C \} \{ # \}

(b) Hardening (Fortition): w \( \rightarrow \) v

UR’s: /# falw #/ /# falw + a + t #/
PR’s: [falu] [falvat]
‘village’ (nominative) ‘village’ (accusative)

-----------------------------

Finnish

(a) Diphthongization: ee \( \rightarrow \) ie

(b) \( g \) Deletion: \( g \rightarrow \emptyset / V \_\_ V \)

UR’s: /vee/ /tege/
PR’s: [vie] [tie]


(ordered rules.pdf)
Your written homework assignment to turn in on Day 8 is the Serbo-Croatian problem (# 3.1) in the Kenstowicz textbook. Follow the instructions in the book. It would be very beneficial to first re-read the discussion in section 3.1. To summarize for you from the book, Kenstowicz posits the following three rules for the data already analyzed:

**Final Stress:**
\[ V \rightarrow [+\text{stress}] / \_ \_ C_0 \# \]

**Epenthesis:**
\[ \emptyset \rightarrow [a] / C \_ \_ C \# \]
\[ [+\text{son}] \]

**l Vocalization:**
\[ l \rightarrow o / \_ \_ \# \]

All three of these rules are crucially ordered with respect to the other two:

Final Stress
\[ \rightarrow \]
Epenthesis
\[ \rightarrow \]
l Vocalization

Each of these three ordering relationships is counterbleeding in nature. The underlying suffixes which Kenstowicz posits are:

\[ \emptyset \text{ ‘masculine’} \]
\[ /-a/ \text{ ‘feminine’} \]
\[ /-o/ \text{ ‘neuter’} \]
\[ /-i/ \text{ ‘plural’} \]

As the book indicates, I would like you to list the Underlying Representation (UR) of each new morpheme in the problem, roots as well as suffixes. Enclose each UR inside diagonal slashes (/) and give its gloss inside single quotation marks (‘). There are fifteen new roots and two new suffixes in these data (the ‘1sg. pres.’ suffix and the past tense suffix). For this set of data you will need to write three new rules (not just two). State each new rule both in prose and formally.
For each new crucial rule ordering that is introduced by your new rules, demonstrate that it is necessary by showing a correct and in incorrect derivation. Remember to mark incorrect surface forms with an asterisk (*). List in a vertical column the names of all six of the rules, arranging them according to the order in which they apply. Connect each pair of crucially ordered rules in the list with an arc, and indicate somewhere what type(s) of ordering relationship(s) the new rules are in. You do not need to show a complete derivation of the words [povéo] and [povelá] (ignore what the book says at this point). You may also ignore the fact that the last two rows of forms do not have the stressed vowel marked (because they are irregular).

Here's an important tip in doing your analysis: pay close attention to the morphology (grammatical glosses of all morphemes), especially when making your initial parse (tentative divisions). This hint may save you some headaches.
# Solution to the Somali problem (exercise 3.5)

**Underlying Representations**

<table>
<thead>
<tr>
<th>(A)</th>
<th>Underlying Form</th>
<th>English Meaning</th>
<th>Extra Mark</th>
<th>Somali Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>/daar/</td>
<td>‘house’</td>
<td>Ø</td>
<td>‘singular’</td>
<td></td>
</tr>
<tr>
<td>/gees/</td>
<td>‘side’</td>
<td>/-ta/</td>
<td>‘singular definite’</td>
<td></td>
</tr>
<tr>
<td>/lug/</td>
<td>‘leg’</td>
<td>/-o/</td>
<td>‘plural’</td>
<td></td>
</tr>
<tr>
<td>/naag/</td>
<td>‘woman’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/tib/</td>
<td>‘pestle’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/sab/</td>
<td>‘outcast’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/bad/</td>
<td>‘sea’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/ʔid/</td>
<td>‘person’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/feeq/</td>
<td>‘rib’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/ul/</td>
<td>‘stick’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/bil/</td>
<td>‘month’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/meel/</td>
<td>‘place’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/kaliil/</td>
<td>‘summer’</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(B)</th>
<th>Underlying Form</th>
<th>English Meaning</th>
<th>Extra Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>/sum/</td>
<td>‘poison’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/laam/</td>
<td>‘branch’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/sim/</td>
<td>‘hip’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/dan/</td>
<td>‘affair’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/daan/</td>
<td>‘riverbank’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/saan/</td>
<td>‘hide’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(C)</th>
<th>Underlying Form</th>
<th>English Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>/nirg/</td>
<td>‘baby female camel’</td>
<td></td>
</tr>
<tr>
<td>/gabḍ/</td>
<td>‘girl’</td>
<td></td>
</tr>
<tr>
<td>/gaifiant/</td>
<td>‘arm’</td>
<td></td>
</tr>
<tr>
<td>/hogl/</td>
<td>‘downpour’</td>
<td></td>
</tr>
<tr>
<td>/bagl/</td>
<td>‘mule’</td>
<td></td>
</tr>
<tr>
<td>/waḥar/</td>
<td>‘female kid’</td>
<td></td>
</tr>
<tr>
<td>/kefed/</td>
<td>‘pan’</td>
<td></td>
</tr>
<tr>
<td>/ʔilin/</td>
<td>‘female dwarf’</td>
<td></td>
</tr>
<tr>
<td>/bohol/</td>
<td>‘hole’</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(D)</th>
<th>Underlying Form</th>
<th>English Meaning</th>
<th>Extra Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>/sug/</td>
<td>‘wait’</td>
<td>/-ay/</td>
<td>‘third person masculine’</td>
</tr>
<tr>
<td>/kab/</td>
<td>‘fix’</td>
<td>/-tay/</td>
<td>‘third singular feminine’</td>
</tr>
<tr>
<td>/sid/</td>
<td>‘carry’</td>
<td>/-nay/</td>
<td>‘first plural’</td>
</tr>
</tbody>
</table>
/dil/ ‘kill’
/gan/ ‘aim’
/tum/ ‘hammer’
/arg/ ‘see’
/gudb/ ‘cross river’
/qosl/ ‘laugh’
/hadl/ ‘talk’

Rules

**Coronal Deletion:** a coronal stop (/t/) deletes after another coronal stop (/d/ or /θ/).

\[
\begin{array}{c}
-\text{sonorant} \\
+\text{coronal} \\
-\text{continuant}
\end{array} \rightarrow \emptyset / \begin{array}{c}
-\text{sonorant} \\
+\text{coronal} \\
-\text{continuant}
\end{array}
\]

**Lenition:** voiced stops become fricatives between vowels.

\[
\begin{array}{c}
-\text{sonorant} \\
+\text{voice}
\end{array} \rightarrow [+\text{continuant}] / V \_ \_ V
\]

**Nasal Neutralization:** the labial nasal (/m/) becomes coronal ([n]) when in syllable-final position.

\[
[+\text{nasal}] \rightarrow [+\text{coronal}] / _ _ \{C\} \{\#\}
\]

In classical generative phonology (the *SPE* model), direct reference to the notion of syllable structure was avoided in formal rules, thus the *disjoint* notation (C or #) in the environment above. This is no longer the case. We would now formalize the triggering environment as a final syllable boundary:

\[
[+\text{nasal}] \rightarrow [+\text{coronal}] / _ _ ]_{σ}
\]
**Vowel Epenthesis**: insert a vowel to break up a syllable-final cluster of two consonants. Make the vowel exactly the same as the vowel in the preceding syllable.

\[
\emptyset \rightarrow V / V C \text{ } C \sigma
\]

\[
[\alpha \text{ FT}] \text{ } [\alpha \text{ FT}]
\]

The following additional rule is needed for section D:

**Nasal Gemination**: a (coronal) nasal totally assimilates to a preceding lateral.

\[
[++\text{nasal}] \rightarrow [+\text{lateral}] / [+\text{lateral}]
\]

**Rule Orderings**

Lenition must precede Coronal Deletion (counterfeeding):

<table>
<thead>
<tr>
<th>right order</th>
<th>wrong order</th>
</tr>
</thead>
<tbody>
<tr>
<td>UR /bad + ta/</td>
<td>UR /bad + ta/</td>
</tr>
<tr>
<td>Lenition -----</td>
<td>Coronal Deletion bada</td>
</tr>
<tr>
<td>Coronal Deletion bada</td>
<td>Lenition baða</td>
</tr>
<tr>
<td>PR [bada]</td>
<td>PR *[baða]</td>
</tr>
</tbody>
</table>

The Vowel Epenthesis rule needs to feed the Lenition rule:

<table>
<thead>
<tr>
<th>right order</th>
<th>wrong order</th>
</tr>
</thead>
<tbody>
<tr>
<td>UR /hogl/</td>
<td>UR /hogl/</td>
</tr>
<tr>
<td>Vowel Epenthesis hogol</td>
<td>Lenition -----</td>
</tr>
<tr>
<td>Lenition hogol</td>
<td>Vowel Epenthesis hogol</td>
</tr>
<tr>
<td>PR [hogol]</td>
<td>PR *[hogol]</td>
</tr>
</tbody>
</table>
The Vowel Epenthesis rule also needs to precede the /lt/ → [š] rule (a counterbleeding relationship):

<table>
<thead>
<tr>
<th>right order</th>
<th>wrong order</th>
</tr>
</thead>
<tbody>
<tr>
<td>UR /hogl + ta/</td>
<td>UR /hogl + ta/</td>
</tr>
<tr>
<td>Vowel Epenthesis</td>
<td>/lt/ Vowel Epenthesis</td>
</tr>
<tr>
<td>/lt/</td>
<td>/lt/</td>
</tr>
<tr>
<td>Lenition</td>
<td>Lenition</td>
</tr>
<tr>
<td>PR [hoγoša]</td>
<td>PR *[hoša]</td>
</tr>
</tbody>
</table>

Finally, the Vowel Epenthesis rule also needs to precede Coronal Deletion, again a counterbleeding relationship:

<table>
<thead>
<tr>
<th>right order</th>
<th>wrong order</th>
</tr>
</thead>
<tbody>
<tr>
<td>UR /gabš + ta/</td>
<td>UR /gabš + ta/</td>
</tr>
<tr>
<td>Vowel Epenthesis</td>
<td>Coronal Deletion</td>
</tr>
<tr>
<td>Lenition</td>
<td>Vowel Epenthesis</td>
</tr>
<tr>
<td>Coronal Deletion</td>
<td>Lenition</td>
</tr>
<tr>
<td>PR [gaβaša]</td>
<td>PR *[gaša]</td>
</tr>
</tbody>
</table>

List of rules

- Vowel Epenthesis
- Lenition
- Coronal Deletion
- /lt/ → [$\ddot{s}$]

Nasal Neutralization

Nasal Gemination

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Indonesian morphophonemics (regularized and simplified)

<table>
<thead>
<tr>
<th>uninflected root</th>
<th>verbalized</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>buat</td>
<td>membuat</td>
<td>make</td>
</tr>
<tr>
<td>baća</td>
<td>membaća</td>
<td>read</td>
</tr>
<tr>
<td>dalam</td>
<td>mendalam</td>
<td>within</td>
</tr>
<tr>
<td>deňar</td>
<td>mendeňar</td>
<td>hear</td>
</tr>
<tr>
<td>zarah</td>
<td>menzarah</td>
<td>particle</td>
</tr>
<tr>
<td>jahit</td>
<td>meňjahit</td>
<td>sew</td>
</tr>
<tr>
<td>gaći</td>
<td>meňgaći</td>
<td>wage</td>
</tr>
<tr>
<td>gambar</td>
<td>meňgambar</td>
<td>draw a picture</td>
</tr>
<tr>
<td>gosok</td>
<td>meňgosok</td>
<td>rub</td>
</tr>
<tr>
<td>anak</td>
<td>meňanak</td>
<td>child</td>
</tr>
<tr>
<td>aňjuŋ</td>
<td>meňaňjuŋ</td>
<td>extension</td>
</tr>
<tr>
<td>ambil</td>
<td>meňambil</td>
<td>take</td>
</tr>
<tr>
<td>erti</td>
<td>meňjerti</td>
<td>understand</td>
</tr>
<tr>
<td>isi</td>
<td>meňisi</td>
<td>fill up</td>
</tr>
<tr>
<td>ikat</td>
<td>meňikat</td>
<td>string</td>
</tr>
<tr>
<td>ukur</td>
<td>meňukur</td>
<td>measure</td>
</tr>
<tr>
<td>undaŋ</td>
<td>meňundaŋ</td>
<td>invite</td>
</tr>
<tr>
<td>latih</td>
<td>melatih</td>
<td>trained</td>
</tr>
<tr>
<td>rambut</td>
<td>merambut</td>
<td>hair</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>20.</td>
<td>rasa</td>
<td>merasa</td>
</tr>
<tr>
<td>21.</td>
<td>manis</td>
<td>memanis</td>
</tr>
<tr>
<td>22.</td>
<td>masak</td>
<td>memasak</td>
</tr>
<tr>
<td>23.</td>
<td>nikah</td>
<td>menikah</td>
</tr>
<tr>
<td>24.</td>
<td>nilai</td>
<td>menilai</td>
</tr>
<tr>
<td>25.</td>
<td>ŋañi</td>
<td>meñañi</td>
</tr>
<tr>
<td>26.</td>
<td>ŋačo</td>
<td>meŋačo</td>
</tr>
<tr>
<td>27.</td>
<td>ŋeoŋ</td>
<td>meŋeoŋ</td>
</tr>
<tr>
<td>28.</td>
<td>waŋi</td>
<td>mewaŋi</td>
</tr>
<tr>
<td>29.</td>
<td>wakil</td>
<td>mewakil</td>
</tr>
<tr>
<td>30.</td>
<td>yakin</td>
<td>meyakin</td>
</tr>
<tr>
<td>31.</td>
<td>pukul</td>
<td>memukul</td>
</tr>
<tr>
<td>32.</td>
<td>padan</td>
<td>memadan</td>
</tr>
<tr>
<td>33.</td>
<td>toloŋ</td>
<td>menoloŋ</td>
</tr>
<tr>
<td>34.</td>
<td>tulis</td>
<td>menulis</td>
</tr>
<tr>
<td>35.</td>
<td>čuči</td>
<td>meñuči</td>
</tr>
<tr>
<td>36.</td>
<td>čatat</td>
<td>meñatat</td>
</tr>
<tr>
<td>37.</td>
<td>kait</td>
<td>meñait</td>
</tr>
<tr>
<td>38.</td>
<td>kirim</td>
<td>meñirim</td>
</tr>
</tbody>
</table>

Instructions for Indonesian morphophonemics problem

Background:

1. The ‘verbalizer’ prefix is added to bare roots in order to convey a verbal meaning. For example, the isolated root \textit{gaji} means ‘wage’, while \textit{mengaji} means ‘to hire or employ’. Similarly, \textit{anak} in isolation is ‘child’, but \textit{meñanak} means ‘to give birth’. The Indonesian data occurring on the other handout today have been regularized and simplified in a number of ways, for the sake of consistency. For instance, with roots # 10 and 19, the actual prefix that is used is \textit{be(r)}- instead of the one appearing here. Similarly, when four of these roots are joined to the verbalizer prefix, they must take a suffix as well. This suffix, /-kan/, occurs with words # 21, 29, 30, and 32 in your data. That is, form # 29 is more accurately pronounced as [mewakilkan], etc. Finally, a native speaker of Indonesian has also informed us that a couple of the glosses seem to be incorrect. For our purposes here you should ignore all of these grammatical complications.

2. This prefix is attached to the root of each word by a morphological rule. Therefore, you do not need to write a phonological rule to “insert” any morphemes. The forms [buat] and [membuat] ‘to make’ are two distinct words (potentially), although they are of course related semantically. The difference between these two words insofar as their underlying forms are concerned is the absence vs. presence of the ‘verbalizer’ prefix.

3. Most of the symbols represent their standard Americanist values.

\begin{itemize}
  \item [č] = [tʃ] = voiceless alveopalatal affricate
  \item [j] = [dʒ] = voiced alveopalatal affricate
  \item [n] = voiced alveopalatal nasal (the closest IPA symbol is [ɲ])
  \item [y] = [j] = voiced palatal glide (approximant)
  \item [r] = [ɾ] = voiced alveolar flap
\end{itemize}

In some cases the letter \textit{e} represents the vowel schwa (/ə/). This fact has no bearing on the solution to this problem.

Solution

The written solution which you are responsible to turn in on Day 11 should consist of the following parts:
1. Underlying Representation

The ‘verbalizer’ prefix has several different allomorphs (surface variants). Make a list of the ones that appear in the data given to you. For each allomorph, enclose its phonetic segments in square brackets and put a hyphen at the end, before the final bracket. For example, in conjunction with words # 1 and 2 the allomorph of the verbalizer prefix that occurs is [mem-]. Please note, however, that you do not need to worry about stating the specific example numbers from the data sheet that correspond to each allomorph. That is, it is sufficient to just list the allomorph [mem-] once; you do not have to add that it appears in # 1, 2, etc. Among all of these allomorphs, choose one as the best underlying form to represent the morpheme as a whole (in the lexicon), and defend your choice. That is, explain, discuss, and justify why you chose the allomorph which you posited. Don’t forget to enclose the underlying form of the prefix in diagonal slashes (/\/) somewhere in your discussion of this point.

2. Rules

Write a rule to describe each phonological process which you observe operating in these data. Give each rule an appropriate name describing what it does (be creative if you want!). Remember to group together any similar alternations and express each rule in a way that is (1) as concise and general as possible, but which also (2) reflects the phonetic naturalness of the process (whenever that is evident), (3) is consistent with all of the data.

State each rule both in prose and formally, using the feature geometry notation we have been studying, based on page 146 of the textbook. Do not formalize any rules with the following type of notation (classical or SPE):

\[
x \rightarrow y / _____ z
\]

3. Rule orderings

If you need to rely on any crucial rule orderings in your solution, demonstrate that they are necessary. For each pair of rules which are crucially ordered, give a right and a wrong derivation illustrating their interaction. Remember to place underlying forms inside diagonal slashes (/\/) and mark incorrect phonetic forms ([xyz]) with an asterisk (*). Also, in each underlying form, include the morpheme boundary between the prefix and the root, marking it with a hyphen (-). Also state what type of ordering relationship characterizes each pair of crucially ordered rules.

4. List of rules

Simply list in a vertical column the names of all your rules, arranging them according to the order in which they apply. Place any crucially ordered rules at the top of the list and connect each pair of ordered rules with an arc. Place any unordered rules at the bottom of the list.
The following guidelines for choosing between alternative analyses are given in order of importance. The three points under (5) are of equal importance.

1. **THE NULL HYPOTHESIS.** Given two solutions, choose the one that entails identical underlying and surface representations, *unless there is evidence to the contrary* (such as complementary distribution, plausible conditioning factors in the environment, etc.). In other words, don’t propose abstract underlying representations unless there is good reason to.

2. **NONSUPPLETION.** Given two solutions, choose the one that allows a single underlying representation for a given morpheme, with all variants derived by rule.

3. **PREDICTABILITY.** Given two solutions, choose the one that minimizes exceptions. In other words, rules that only apply to certain arbitrary classes of words and not to other phonetically similar sets of words are to be avoided whenever possible.

4. **SIMPLICITY.** Given two solutions, choose the one that is simpler. A solution with fewer rules is (usually) simpler than one with more rules. A rule requiring fewer features and symbols (such as V, C, #) is simpler than a rule with more features and symbols. Usually, the simpler a solution is the more general it is also. This simplicity criterion therefore implies that more general solutions are preferred over less general ones.

5. **PHONOLOGICAL CONDITIONING.** Given two solutions, choose the one that minimizes reference to grammatical information. This includes reference to grammatical categories (noun, verb, etc.) in phonological rules, as well as reference to morpheme (+) boundaries.

**NATURALNESS.** Given two solutions, choose the one that makes use of phonetically motivated (reasonable) rules. Such rules *usually* (but not always) refer to the same feature(s) in the specified *change* and in the *environment*.

**MARKEDNESS.** Given two solutions, choose the one that allows the least marked underlying inventory of phonemes. (*Marked* means rare or unusual in languages universally.) For example, it is very marked to have voiced stops but no voiceless stops underlingly. Therefore, a solution having all surface [t]’s derived from underlying /d/’s is more marked than having the [d]’s derived instead from /t/’s.

source: Stuart Milliken, © 1984. Used with permission.
Some practical tips on writing formal rules using feature geometry trees

On paper, it may appear that feature geometry rules are more complex and cumbersome than rules formalized with the classical notation. In a sense this is only an illusion. There are some very basic and important distinctions between the two models. We will focus on these theoretical issues in an upcoming lecture and explain why feature geometry is a much better approach in the long run. For the moment we highlight here some of the mechanical differences that are helpful to keep in mind when working with feature geometry trees.

In the first place, phonological processes of assimilation are preferably expressed by *spreading* a feature or node which is already present in the environment triggering the change. Consider a rule whereby an obstruent becomes voiced immediately preceding a voiced consonant:

\[(1) \quad [-\text{sonorant}] \rightarrow [+\text{voice}] / \quad \underline{\text{C}} \quad [+\text{voice}]\]

In our new model this would be expressed as follows:

\[(2) \quad \begin{array}{c}
\text{C} \\
\text{[-sonorant]} \\
\text{Pharyngeal} \\
\text{Glottal} \\
\text{[+voice]}
\end{array} \quad \begin{array}{c}
\text{C} \\
\text{Root} \\
\text{Pharyngeal} \\
\text{Glottal} \\
\text{[+voice]}
\end{array}\]

Spreading is visually depicted by a dotted association line. This indicates the addition of a new association line in exactly that location. For example, if rule (2) above were broken down into a “before” and an “after” phase, it would look like this:

\[(3) \quad \begin{array}{c}
\text{C} \\
\text{[-sonorant]} \\
\text{Pharyngeal} \\
\text{Glottal} \\
\text{[+voice]}
\end{array} \quad \begin{array}{c}
\text{C} \\
\text{Root} \\
\text{Pharyngeal} \\
\text{Glottal} \\
\text{[+voice]}
\end{array} \quad \text{→} \quad \begin{array}{c}
\text{C} \\
\text{[-sonorant]} \\
\text{Pharyngeal} \\
\text{Glottal} \\
\text{[+voice]}
\end{array} \quad \begin{array}{c}
\text{C} \\
\text{Root} \\
\text{Pharyngeal} \\
\text{Glottal} \\
\text{[+voice]}
\end{array}\]
This makes it obvious why it is simpler to use a dotted association line as in (2), saving us a lot of time and space. Spreading can go from right-to-left (as in (2)) or from left-to-right, but it always goes upwards, never downwards. It may be helpful (although not necessary) to draw in a pointed arrow at the top of the dotted association line to show the direction of spreading, as follows:

(4) (a) correct:  
\[
\begin{align*}
\text{C} & \quad \text{C} \\
[-\text{sonorant}] & \quad \text{Root} \\
\text{Pharyngeal} & \quad \text{Pharyngeal} \\
\text{Glottal} & \quad \text{Glottal} \\
[+\text{voice}] & 
\end{align*}
\]

(b) incorrect:  
\[
\begin{align*}
\text{C} & \quad \text{C} \\
[-\text{sonorant}] & \quad \text{Root} \\
\text{Pharyngeal} & \quad \text{Pharyngeal} \\
\text{Glottal} & \quad \text{Glottal} \\
[+\text{voice}] & 
\end{align*}
\]

When connecting a new association line via spreading, make sure that the top of it (i.e., the arrow tip, if this is included) comes \textit{underneath} the relevant node in the tree (as in (4a)), not to the side or above the node:

(5) (a) correct:  
\[
\begin{align*}
\text{C} & \quad \text{C} \\
[-\text{sonorant}] & \quad \text{Root} \\
\text{Pharyngeal} & \quad \text{Pharyngeal} \\
\text{Glottal} & \quad \text{Glottal} \\
[+\text{voice}] & 
\end{align*}
\]

(b) incorrect:  
\[
\begin{align*}
\text{C} & \quad \text{C} \\
[-\text{sonorant}] & \quad \text{Root} \\
\text{Pharyngeal} & \quad \text{Pharyngeal} \\
\text{Glottal} & \quad \text{Glottal} \\
[+\text{voice}] & 
\end{align*}
\]

(c) incorrect:  
\[
\begin{align*}
\text{C} & \quad \text{C} \\
[-\text{sonorant}] & \quad \text{Root} \\
\text{Pharyngeal} & \quad \text{Pharyngeal} \\
\text{Glottal} & \quad \text{Glottal} \\
[+\text{voice}] & 
\end{align*}
\]

Another detail to keep in mind is that the same exact node should dominate the spreading feature in both trees (the target and the trigger of the rule):
At times certain tree diagrams are simplified by leaving out intervening nodes and connecting the spreading feature or node directly to the top of the tree. This is an informal shortcut, sort of like using $\alpha$ Place instead of $\pm$coronal, $\pm$anterior, $\pm$distributed etc. in the classical model:

While it is okay to do this in course handouts and similar materials, technically it is an imprecise practice that should be avoided in more serious works such as papers submitted for publication, textbooks, etc. In general you should not take the liberty of doing this in homeworks, tests, etc., unless instructed to the contrary.

Association lines in feature trees are always subject to two important constraints. In the first place, they should never cross over each other. Plan ahead in order to avoid this problem:
Rule (8a) above says that a low vowel becomes mid when the preceding syllable contains a mid vowel.

Secondly, association lines must be straight, never curved. Otherwise it would be possible to undermine and get around the prohibition against crossing lines, in effect.

When two or more binary terminal features are dominated by the same node in the tree, each one should be placed in its own unique matrix (square brackets) with a separate association line, not stacked on top of each other using a single line:

The tree in (9a) describes a segment like [i].

To formalize a deletion rule in the feature geometry model, draw a circle around the timing unit (C or V or X) at the top of the tree and then write in the arrow and null symbol. It normally does not matter which direction the arrow points (up, down, left, right); do it however is most convenient and uncluttered with respect to the rest of your rule:
Rule (10) says to delete a lateral consonant (like [l]) which is immediately followed by an aspirated consonant (or [h]).

Another way in which the deletion of individual features and/or nodes is sometimes depicted is by *delinking*. This refers to the deletion of an association line and is graphically indicated by drawing two short, parallel lines in the middle of a regular association line, at right angles to it:

The rule in (11) above says to delink (delete) the association line connecting a syllable-final consonant with its Glottal Node. This would have the effect of devoicing an obstruent in that position, for example, assuming that “floating” (unattached) features and nodes are simply eliminated at the end of the derivation since they cannot be phonetically implemented (realized). In such a case there would be a default redundancy rule such as [–sonorant] → [–voice] that would fill in the correct surface values of the relevant features. When a node is delinked, all of the other nodes and features which it dominates (implicitly or explicitly) are also detached.

When a feature spreads from one tree to another segment in its environment, you might be worried that this is incompatible with another feature (or the inverse of the same feature) which may already be specified there. To illustrate, let us reconsider rule (8a) above. What if the target which is receiving the feature [–low] (the vowel on the right) is prespecified for [+low], such as an /a/? In such a case we might go ahead and add the feature [+low] in the structural description of the rule, but if we do this then we also need to delink this feature at the same time as the
spreading occurs. These two operations can be assumed to apply simultaneously. The following diagram shows a different way in which we might alternatively express the process from (8a):

(12)  

\[
\begin{array}{c}
\text{V} \\
\text{Root} \\
\text{Oral} \\
\text{Dorsal} \\
[-\text{high}] \\
\end{array} \quad \begin{array}{c}
\text{C} \\
\text{Root} \\
\text{Oral} \\
\text{Dorsal} \\
[-\text{low}] \\
\end{array} \quad \begin{array}{c}
\text{V} \\
\end{array}
\]

In (12) it is necessary to delink [+low] since this feature and [–low] are incompatible with each other (mutually exclusive) when realized at the same time. That is, we cannot simultaneously lower our tongue body and not lower it. However, this type of delinking is something that our theory should do for us automatically. We should not need to stipulate delinking in rule after rule in a situation of this kind. So let us assume that whenever a phonological process spreads a feature or node which conflicts with one that is already present, that rule automatically delinks the prespecified feature. Given this, we can formalize rules more simply as in (8a), rather than as in (12).

Nevertheless, a word of caution is in order. In some cases we do want opposite feature values to exist within the same segment. An example of this would be complex segments such as affricates. In non-linear theories these are typically represented as a stop followed by a fricative, both attached to the same timing element:

(13) informal characterization of an affricate:

\[
\begin{array}{c}
\text{C} \\
[-\text{continuant}] \\
\end{array}
\]

Notice that in this case the contradictory features are not articulated at the same time, but rather sequentially, one after the other. An analogous example would be double stops such as [kp]. These would be geometrically diagrammed as having both a Labial Node and a Dorsal Node underneath a single Oral Node. These two anatomical gestures are not incongruous with each other. So we do not always want to avoid multiple or opposite feature specifications dominated by the same Root Node.

When spreading a feature or a node to an adjacent tree, any intervening nodes that would not otherwise be expressed are automatically filled in along with the appropriate dotted association lines. The universal mechanism which ensures that this is done is called the “Node Generation Convention”: 
In (14) above we are making a vowel nasalized when it is followed by a syllable-final nasal consonant.

Recall that the Dorsal Node in the feature geometry tree dominates three binary terminal features:

If some process tells us to spread the Dorsal Node from one segment to another segment, all three of these features go along with the Dorsal Node automatically (for free). This is true regardless of whether they are overtly mentioned in the rule or not. It is a consequence of the domination relationship. The same is also true of all other nodes, such as Oral, Coronal, etc. If you analyze a process as involving the spread of just one terminal feature under a node (to the exclusion of other binary features dominated by that same node), you cannot formalize this by spreading the whole node. Rather, in such a situation you must spread only one single terminal feature, by itself. In other words, when a particular node dominates three features or more, you can spread all of them simultaneously (by spreading that node), or you can spread just one of them, but you cannot spread exactly two of them in the same rule. It is either just one feature, or else all of them, but not some. A central and important claim of feature geometry theory is that any time we encounter a situation requiring us to spread a subset of features under a node, such as two out of three or three out of four, then that is in reality not a single, unitary phonological process. Rather, in such a case we would have to spread the terminal features one-by-one, each with a separate rule. So in general, when formalizing an assimilation process, try to spread the highest node in the tree whenever you can, but be aware that this implies the simultaneous assimilation of all other features and nodes subsumed underneath the higher node.

In formal rules you can refer to nodes by placing their names right where they occur in the tree, or else by drawing in a little circle and writing the name of the node off to the side. But it’s probably best not to mix these two systems in the same rule. And be careful to put the square
brackets only around terminal features, not nodes (except when specifying a value for
\([\pm \text{sonorant}]\) and/or \([\pm \text{consonantal}]\) within the Root Node). This is because nodes are different
from binary features in the sense that nodes do not have a minus value. In other words, it is
impossible to refer to the absence of a node in a formal rule:

\begin{itemize}
\item[(16a)] correct:
\item[(16b)] correct:
\item[(16c)] incorrect:
\end{itemize}

\begin{center}
\begin{tabular}{ccc}
\text{C} & & \text{C} \\
\text{Root} & \circ & \text{Root} \\
\text{Oral} & & \text{Oral} \\
\text{Coronal} & \circ & \text{Coronal} \\
\text{[+anterior]} & & \text{[+anterior]} \\
\end{tabular}
\end{center}

The trees in (16a) and (16b) above depict an alveolar or dental consonant.

A final matter to point out is that, when we draw a feature tree, the only details which count as a
language-particular stipulation (complication) are the binary features. All the rest of the structure
comes along for free (automatically), as a consequence of Universal Grammar (our theory). This
includes all of the nodes as well as the corresponding association lines that connect them, plus
their hierarchical relationships, because these are “built-in,” so to speak. For example, in the
trees in (16a) and (16b) above, the only language-specific “cost” is the terminal feature
[+anterior]. When looked at in this way, feature geometry mechanisms are not really more
cumbersome than the formal devices of the classical model (in a linguistic sense), even though
they may look like they are.
• Autosegmental phonology arrived on the scene in the middle of the 1970’s.
• At first the insights of autosegmental theory were applied primarily to tonal phenomena, as we have seen.
• These innovations began an important movement which has been called “non-linear” phonology, cf. syllable structure, metrical structure, feature geometry, etc. The new views of non-linear autosegmental phonology eventually led to the Feature Geometry concept in the mid 1980’s.
• The arrangement of features into a distinct geometric hierarchy has several advantages when compared to the classical view of feature organization:
  1. The formalism of spreading more directly describes assimilation as a sharing of the same articulatory gesture than does the changing of the value of a feature in a matrix; thus it is physiologically more intuitive.

  cf.
  \[ C \rightarrow [+\text{voice}] / \_ \_ [+\text{voice}] \]
  versus
  \[
  \begin{array}{c}
  \text{Root} \\
  \text{Pharyngeal} \\
  \text{Glottal} \\
  \hline
  [+\text{voice}]
  \end{array}
  \]
• In other words, in the feature geometry tree we have a single feature or node simultaneously shared by two adjacent timing units or segments. So the formalism itself directly shows what is going on in our vocal tracts in a more explicit way.

• (2) Similarly, Feature Geometry makes natural processes easy to formalize and unnatural processes more difficult to formalize, even more so than the classical formalisms did.
• Now there is no direct and simple way to spread a feature which is not already present in the environment.
• In terms of the evaluation metric of classical generative phonology, the following rule would be considered equally as simple and natural as the voicing rule given above, since it requires the same number of features to be specified:

  \[ [+\text{aspirated}] \rightarrow [+\text{consonantal}] / \_ \_ [+\text{distributed}] \]
• which is totally bizarre, and not attested in any language.
• In terms of the classic model, which just counted up the number of things that have to be stipulated, all of the following rules would be considered equally complex:

  \[
  \begin{array}{c}
  C \rightarrow [+\text{voice}] / \_ \_ [+\text{voice}] \\
  C \rightarrow [+\text{voice}] / \_ \_ [+\text{voice}] \\
  C \rightarrow [+\text{voice}] / \_ \_ [+\text{voice}] \\
  C \rightarrow [+\text{voice}] / \_ \_ [+\text{voice}] \\
  C \rightarrow [+\text{back}] / \_ \_ [+\text{voice}] \\
  \end{array}
  \]
• (3) The hierarchical arrangement of features allows us to manipulate more than one feature at a time as part of a bundle or node.
• In a language such as Indonesian, which has four primary points of articulation for consonants, a nasal assimilation rule would have to account for the following sequences:

  \[
  \begin{array}{c}
  \text{mp} \\
  \text{nt} \\
  \text{nh} \\
  \text{nk} \\
  \text{mb} \\
  \text{nd} \\
  \text{nj} \\
  \text{ng}
  \end{array}
  \]
• This would require two variable features to capture the relevant places of articulation:

  \[
  \begin{array}{c}
  \text{Root} \\
  \text{Nasal} \\
  \text{Oral} \\
  \hline
  [+\text{nasal}] \\
  \end{array}
  \]
• Nevertheless, we really don’t want to say that the nasal assimilation rule for Spanish is any less natural than the one for Indonesian, even though it uses one more feature.
• With feature geometry, we can express these two rules in exactly the same way, capturing the fact that what is involved is really the exact same process in both languages:

  \[
  \begin{array}{c}
  \text{Root} \\
  \text{Nasal} \\
  \hline
  [+\text{nasal}] \\
  \end{array}
  \]

• However, for languages such as Spanish or English, which exploit more point of articulation differences, we would need to include a third feature such as [distributed]:

  \[
  \begin{array}{c}
  \text{mp} \\
  \text{mf} \\
  \text{nt} \\
  \text{ns} \\
  \text{nh} \\
  \text{nk} \\
  \text{etc.}
  \end{array}
  \]

  \[
  \begin{array}{c}
  \text{C} \\
  [+\text{nasal}] \\
  \end{array}
  \]
  \[
  \begin{array}{c}
  \text{C} \\
  [+\text{nasal}] \\
  \end{array}
  \]
  \[
  \begin{array}{c}
  \text{C} \\
  [+\text{nasal}] \\
  \end{array}
  \]
  \[
  \begin{array}{c}
  \text{C} \\
  [+\text{nasal}] \\
  \end{array}
  \]
  \[
  \begin{array}{c}
  \text{C} \\
  [+\text{nasal}] \\
  \end{array}
  \]
  \[
  \begin{array}{c}
  \text{C} \\
  [+\text{nasal}] \\
  \end{array}
  \]
  \[
  \begin{array}{c}
  \text{C} \\
  [+\text{nasal}] \\
  \end{array}
  \]
• This is because when we spread a node such as Oral cavity (or Place), all of the other nodes and terminal features which are dominated by it come along for a free ride, regardless of whether they are specified explicitly, or just left implicit.

• Similarly, when we delink (disassociate) a node in the tree, all of the features subsumed under it are also automatically deleted. For example, consider a language like Korean, which has contrastive voiced stops, aspirates, and ejectives. These surface unchanged in syllable onsets, but in coda position they are neutralized such that all of them are realized as plain, voiceless plosives. In the classical model this rule would require a change in three separate features:

\[ \begin{align*}
\text{[–sonorant]} & \rightarrow \text{\begin{tabular}{l}

\text{voice} \\
\text{spread glottis} \\
\text{constricted glottis}
\end{tabular}} & \text{–voice} \\
\sigma & \text{–spread glottis} \\
\text{–constricted glottis}
\end{align*} \]

• In the feature geometry model, on the other hand, all we have to do is delink the Glottal Node in the relevant environment:

\[ \begin{align*}
\text{C} & \rightarrow \text{\begin{tabular}{l}

\text{[–sonorant]} \\
\text{Pharyngeal} \\
\text{Glottal}
\end{tabular}}
\end{align*} \]

• One of the most important and fundamental claims of the feature geometry movement is that any phonological process which is truly assimilatory in nature should be able to be represented formally by the addition of a single association line somewhere in a feature tree.

• In other words, assimilation = spreading, and spreading = assimilation.

• Therefore, the model of feature geometry which we use must be set up in such a way that any group of two or more features which can be jointly assimilated by a single rule must be exhaustively and uniquely dominated by the same node somewhere in the feature tree.

• These pressures have led to many revisions and modifications of the feature tree, and phonologists are still not in total agreement about which features and nodes (as well as their hierarchical arrangement) will ultimately lead to the ideal tree configuration.

• Another way of looking at all this is the following: in the classical model, that fact that features such as [anterior], [coronal], and sometimes [distributed] occurred together over and over again in many similar rules was to certain degree accidental. There was no independent, a priori explanation for why these combinations occurred rather than, say, [anterior] and [voice], or [coronal] plus [aspirated], etc.

• Previously, [+distributed] included bilabials along with alveopalatals, but no known phonological process makes reference to this whole group (to the exclusion of other points of articulation).

• (5) Feature geometry more directly explains and predicts why certain segments do and do not exist in the languages of the world.

• In other words, feature geometry theory more adequately accounts for why the sounds that do occur, can occur, and why the sounds that do not occur, cannot occur.

• For example, using a linear-type matrix, imagine a hypothetical language with a new sound that is characterized by the following combination of feature specifications:

\[ \begin{align*}
\text{[+round]} & \rightarrow \text{[+labial]}
\end{align*} \]

• In the classical model there is no way to directly avoid this contradiction, except by fixing it later with a redundancy rule:

\[ [\text{+round}] \rightarrow [\text{+labial}] \]

• In the geometric model this is done for us automatically, since now the only possible way to access the feature [round] is by means of invoking the presence of the Labial Node. In other words, it was built into the theory by Universal Grammar to begin with.

• (6) The classical model of assimilation regularly violates the Obligatory Contour Principle, which says that at the melodic level, adjacent identical elements (or features or specifications) are prohibited.

• This principle is very important since it governs representations on the tonal tier. For example, the Obligatory Contour Principle requires that identical adjacent tones be multiply linked rather than associated one-to-one.
• The difference in these two configurations makes important predictions which have been empirically confirmed by many tonal languages.
• Changing a feature value to be identical to that of an adjacent matrix is how the classical generative model conceives of assimilation, and this is at odds with the Obligatory Contour Principle.
• The feature geometry model, on the other hand, always obeys this because it equates assimilation with the spreading of a feature or node that is present in the environment which triggers a rule.
• In summary and in conclusion:

<table>
<thead>
<tr>
<th>H</th>
<th>*</th>
</tr>
</thead>
<tbody>
<tr>
<td>C V C V</td>
<td>C V C V</td>
</tr>
</tbody>
</table>

• The ultimate test to evaluate a linguistic model is NOT what it looks like on paper.
• The ultimate test to evaluate a linguistic model is NOT how much ink it takes to write up its formalisms.
• The ultimate test to evaluate a linguistic model IS what you can and cannot do with it.
• One of the fundamental goals of phonological theory is to make common, natural processes easy to formalize, to make uncommon and unnatural processes more cumbersome to formalize, and to make unattested processes impossible to formalize, and the feature geometry model does all of these things much better than the classical model does.

• In other words, there are important reasons why we do things the way we do.
• A non-formal description of a language does not really account for anything, and it does not really explain anything.
• Linguistic formalisms make a claim about what is really happening in processing a language in our minds and in our vocal tracts, and they should help us explain why the world is the way it is.
Instructions for the Icelandic exercise

Your written homework assignment to turn in on Day 13 is the Icelandic problem (# 5.1) in the Kenstowicz textbook. Do part A only. Ignore part B.

For two of the three phonological processes (syncope and /r/ assimilation), formalize them both with the classical model (SPE) and feature geometry. For the third process (umlaut), formalize it in classical terms only, but then discuss how you might hypothetically try to formalize it using feature geometry. What problems and issues arise for the umlauting rule with Kenstowicz’s model of feature geometry? For all of these rules, express their corresponding generalizations in prose as well. For your syncope rule, make sure that the form [jaki] is not a counterexample. There is also a different rule that changes /a/ to [e] in the data in section (2b). You can ignore this last rule, meaning that you don’t need to worry about trying to formalize it, in either of the two models.

Determine the relative order between the umlaut and syncope processes, and demonstrate this with a sample derivation. In your discussion, mention what type(s) of crucial rule relationships are involved (bleeding, etc.)

Comparing the data in (2) with the data in (3), a rule ordering paradox (contradiction) arises. Provide a solution to this problem. Explain, discuss, and illustrate your analysis with a sample derivation of one or more crucial forms.

Note: in the data in (3), one of the roots appears to exhibit an alternation between a singleton [g] and a geminate [gg]. Ignore this fact, i.e., don’t worry about trying to account for it.
The model of lexical phonology

LEXICON (list of morphemes – words and stems)

Lexical component

Underlying Representation

underived lexical entries

morphological rules

cyclic phonological rules

postcyclic phonological rules

derived (affixed) lexical entries

Lexical Representation

syntax

Lexical component

postlexical phonological rules

Phonetic Reportaent

output of phonology
Distinctions between lexical and postlexical rules (the “lexical syndrome”)

<table>
<thead>
<tr>
<th>LEXICAL RULES</th>
<th>POSTLEXICAL RULES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. may refer to word-internal morphological structure</td>
<td>1. cannot refer to word-internal morphological structure (due to the Bracket Erasure Convention)</td>
</tr>
<tr>
<td>2. may be sensitive to morpheme boundaries</td>
<td>2. cannot be sensitive to morpheme boundaries</td>
</tr>
<tr>
<td>3. may not apply across word boundaries</td>
<td>3. may apply across word boundaries</td>
</tr>
<tr>
<td>4. may be cyclic</td>
<td>4. cannot be cyclic</td>
</tr>
<tr>
<td>5. if cyclic, then subject to the Strict Cycle Condition</td>
<td>5. non-cyclic, hence apply across-the-board (everywhere), and only once</td>
</tr>
<tr>
<td>6. may be restricted to applying only in derived environments (by the Strict Cycle Condition)</td>
<td>6. may not be restricted to applying only in derived environments</td>
</tr>
<tr>
<td>7. must obey Structure Preservation (can’t create non-contrastive sounds)</td>
<td>7. may violate Structure Preservation (can create non-contrastive sounds)</td>
</tr>
<tr>
<td>8. may have lexical exceptions (counterexamples)</td>
<td>8. cannot have lexical exceptions</td>
</tr>
<tr>
<td>9. must precede all postlexical rules</td>
<td>9. must follow all lexical rules</td>
</tr>
<tr>
<td>10. produce changes which are generally obvious to the consciousness of native speakers</td>
<td>10. produce changes which native speakers are generally unaware of (“allophonic” rules)</td>
</tr>
<tr>
<td>11. apply categorically</td>
<td>11. may apply gradiently</td>
</tr>
<tr>
<td>12. apply to lexical categories only (nouns, verbs, adjectives, and adverbs)</td>
<td>12. apply to both functional and lexical categories</td>
</tr>
<tr>
<td>13. disjunctively ordered with respect to other lexical rules (due to the Elsewhere Condition)</td>
<td>13. conjunctively ordered with respect to lexical rules (and other postlexical rules?)</td>
</tr>
<tr>
<td>14. diachrony: lexical diffusion</td>
<td>14. diachrony: neogrammarian sound change (no exceptions)</td>
</tr>
<tr>
<td>15. have weak or no effects in on-line tasks (nonce words, secret languages, experiments, foreign-language learning)</td>
<td>15. have effects in on-line tasks</td>
</tr>
</tbody>
</table>

sources:

**Illustration of lexical phonology: English [ŋ]**

<table>
<thead>
<tr>
<th></th>
<th>‘finger’</th>
<th>‘long’</th>
<th>‘longer’ (adj.)</th>
<th>‘longer’ (noun)</th>
<th>‘sing’</th>
<th>‘singer’</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Underlying Representation</strong></td>
<td>[fɪŋr]</td>
<td>[lɔŋ]</td>
<td>[lɔŋ]</td>
<td>[lɔŋ]</td>
<td>[sɪŋ]</td>
<td>[sɪŋ]</td>
</tr>
<tr>
<td><strong>Level 1 Affixation</strong></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>(inflectional)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[long]r</td>
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<td></td>
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<td></td>
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<tr>
<td><strong>Bracket Erasure</strong></td>
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<tr>
<th></th>
<th>[fɪŋgr]</th>
<th>[lɔŋ]</th>
<th>[lɔŋgr]</th>
<th>[lɔŋr]</th>
<th>[sɪŋ]</th>
<th>[sɪŋr]</th>
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<tbody>
<tr>
<td><strong>Level 2 Affixation</strong></td>
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<td></td>
<td></td>
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<tr>
<td>(derivational)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[long]r</td>
<td>[sɪŋ]</td>
<td>[sɪŋr]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bracket Erasure</strong></td>
<td></td>
<td>[lɔŋr]</td>
<td></td>
<td></td>
<td>[sɪŋr]</td>
<td></td>
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<thead>
<tr>
<th></th>
<th>[fɪŋgr]</th>
<th>[ləŋ]</th>
<th>[ləŋgr]</th>
<th>[ləŋr]</th>
<th>[sʊŋ]</th>
<th>[sʊŋr]</th>
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<tbody>
<tr>
<td><strong>Laxing</strong></td>
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<tr>
<th></th>
<th>[fɪŋgr]</th>
<th>[ləŋ]</th>
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<th>[ləŋr]</th>
<th>[sʊŋ]</th>
<th>[sʊŋr]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phonetic Representation</strong></td>
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</tbody>
</table>
A hallmark of the theory of generative phonology has been the use of phonological rules to account for allomorphic alternations and allophonic variation. In the tradition represented most vividly by Chomsky and Halle’s (1968) book *The Sound Pattern of English*, phonological rules are conceived of as essentially a monolithic block of rules that apply in a specified order, the first rule applying to the underlying forms of the concatenated morphemes, and each successive rule applying to the output of the preceding rules. This is illustrated by the application of several rules of Seri [a language spoken in Mexico, S.P.] to derive the words for ‘didn’t you look for it?’, ‘didn’t you make it?’, and ‘did you make it?’ in the example below.

| Underlying: | m-t-m-kaa | m-t-m-aai | m-t-aai |
| R1:         | mtkkáa    | mtkmáai  | mtáai   |
| R2:         | mtkmkáa   | mtkmáai  | -----   |
| R3:         | mtkomkáa  | -----    | -----   |
| R4:         | intkomkáa | intkmáai | inttáai |
| R5:         | intkoŋkáa | intkmáai | inttáai |
| R6:         | -----     | intkwáai | -----   |
| R7:         | -----     | intkwáai | -----   |
| Phonetic:   | intkoŋkáa | intkwáai | inttáai |

In the past decade, this conception of phonology has been challenged in several ways. One challenge has been to the view of the rules as one monolithic set. I will not go into the history of the development of these ideas (see Kenstowicz (1994) for a fairly up-to-date recapitulation), but will try to present what appears to be the result of about a dozen years of research within the framework known as Lexical Phonology.

**Strata**

It is commonly claimed now that phonological rules are organized into various levels, or *strata*, of application. A given rule may apply at more than one level, and it may be necessary to stipulate the strata in which a rule applies.⁠²⁷ There is no universal claim as to how many strata a language may have.

---

¹Kiparsky suggested that the parameter is quite simple: at what level must a rule cease to apply? This is known as the Strong Domain Hypothesis. (See Myers 1991 for more discussion and references.) Under this view, any rule may apply as early as it is allowed by general constraints (such as Structure Preservation, discussed below.)
Some of the strata have word-internal, *lexical*, domains; and some of the strata pertain to words after they are concatenated into phrases. The latter are commonly called *postlexical* strata.\(^2\)

---

**Stratum v**

↓

**LEXICAL STRATA**

↓

**Stratum w**

…………

Syntactic rules adjoining words

↓

**POSTLEXICAL STRATA**

↓

**Stratum z**

The distinction between ‘lexical’ and ‘postlexical’ rules was once hailed as the major rule classification, and some people have been intrigued by the similarity between this and the structuralists’ distinction between morphophonemic rules and allophonic rules. However, this distinction has been very seriously undermined by much of the detailed work carried out within Lexical Phonology itself.\(^3\)

A major parameter relevant to the application of phonological rules is *cyclicity*. Each stratum is identified as being either cyclic or noncyclic, and there is apparently no universally valid way to predict which strata will be cyclic or noncyclic.\(^4\) Therefore, a rule may apply cyclically or noncyclically, as I explain below, depending on the stratum in which it applies. Sometimes, a rule is said to be cyclic or to be noncyclic, but this is an oversimplification since in this approach to phonology the same rule may apply in more than one stratum, and potentially in more than one fashion.

**Cyclic vs. Noncyclic Rule Application**

A rule that applies cyclically makes crucial reference to the morphological structure of the words in very specific ways. In fact, Lexical Phonology claimed that this is so because they are actually interleaved with the word formation rules themselves.\(^5\)

The most well-known cyclic rules in the tradition of standard generative phonology were stress rules; the application of stress rules in successively larger domains from the inside out

\(^2\)The existence of more than one such postlexical stratum is a relatively new idea. See Kaisse 1987, and Halle, Harris and Vergnaud 1991; the matter is also discussed in Kenstowicz (in press). According to the earlier literature, postlexical rules typically have the behavior of noncyclic rules (see below).

\(^3\)Even the distinction between rules with exceptions and rules without exceptions does not correlate well with the lexical vs. postlexical classification.

\(^4\)The cyclic vs. noncyclic characteristic is not widely discussed for postcyclical rules.

\(^5\)Halle, Harris and Vergnaud 1991 and Halle and Kenstowicz 1991 do not adopt this view of the interaction between morphology and phonology, however, thereby distancing themselves from the ‘standard’ theory of Lexical Phonology as presented in Kiparsky 1982 and Mohanan 1986.
provided an analysis of complex stress patterns. However, other rules are also claimed to be cyclic in their application. For example, Pulleyblank 1986 argues that tone rules in various languages are also cyclic rules.

But the idea of cyclicity is now conceptually much broader (with the name being somewhat misleading). Trisyllabic Shortening in English is commonly considered to be a rule that applies in a cyclic stratum. Like the cyclic stress rules, it applies within a specified morphological domain which is not coterminal with the word boundary. The “o” in a word such as [[ōmen]ous] undergoes the rule (changing the “long o” to “short o”), because the suffix –ous forms a cyclic constituent, but the “o” in a word such as [[cōzi]ness] does not undergo the rule because the suffix –ness does not form a cyclic constituent. The suffix –ness, unlike –ous, does not contribute to the context needed for the shortening rule to operate.

One might represent this formally by letting an affix such as –ous mark the constituent which it forms with a bracket labeled as cyclic: [[ōmen]ous]. This would contrast with a noncyclic bracket, as in [[cōzi]ness]. In a cyclic stratum, phonological rules are applied cyclically to each cyclic constituent. In a noncyclic stratum, rules apply once to the entire domain. (Stems always define a cyclic constituent.)

It is widely claimed that when a structure-changing rule (such as one that changes features that are present underlyingly) applies in a cyclic stratum, it must obey the Strict Cycle Condition. In simple words, a rule that obeys the Strict Cycle Condition is only allowed to apply to phonological material that is “new” on that cycle. It may be new because some morpheme has been added that contributes to the context (as in the case of ominous), or it may be new because some rule has altered the phonological string since the beginning of that stratum. Phonological material that comes directly from the lexicon or from some previous stratum is not looked at by the rule. As a rule that applies in a cyclic stratum, Trisyllabic Shortening in English obeys this constraint. Although many monomorphemic words like īvory have a “long” vowel in the right place for Trisyllabic Shortening to apply, the rule is prevented from applying because of the Strict Cycle Condition.

Rules which apply in a noncyclic stratum are not constrained by the Strict Cycle Condition. For example, consider the rule of Vowel Shift in English which derives [divayn] from underlying divīn (compare divinity). This rule must be allowed to apply to a string which (except for stress) is unchanged from its lexical form. Similarly, the rule deleting the final b of words such as bomb (compare bomb-ard) does not obey the Strict Cycle Condition. Rules such as Flapping and Aspiration in English, which apply in words such as atom and atomic, respectively, do not obey the Strict Cycle Condition since they may apply entirely morpheme-internally.

---

6Halle and Kenstowicz 1991 dispute the factual basis for earlier accounts of English stress and propose an analysis which is quite different from previous cyclic accounts.

7There is no account that accurately predicts which affixes in English form cyclic constituents and which form noncyclic constituents.

8This labeling of brackets is found in Halle, Harris and Vergnaud 1991. In standard Lexical Phonology, each of these affixes would be assigned to a particular stratum. But if morphology is not interleaved with phonology, then some other means of identifying cyclic constituents (such as the superscripting device) is needed.

9The English stress rule is not viewed as structure-changing. Therefore, although it applies in a cyclic stratum, it does not have to obey Strict Cyclicity.
The noncyclic stratum in which the Vowel Shift rules applies is crucially ordered after the cyclic stratum in which Trisyllabic Shortening applies. Thus Trisyllabic Shortening applies to the form *divēn-ity*, depriving Vowel Shift of one form to which it would otherwise apply.

Facts of German also support a distinction between cyclic and noncyclic rule application. Rubach 1990 claims that syllabification in German applies cyclically but that Syllable-final Devoicing applies noncyclically. This difference permits a simple solution to a complex array of facts. This is shown by the following derivation.10

<table>
<thead>
<tr>
<th>Syllabif.</th>
<th>‘act’</th>
<th>‘handy’</th>
</tr>
</thead>
<tbody>
<tr>
<td>h a n d l</td>
<td>ung</td>
<td>hand l i c h</td>
</tr>
<tr>
<td>h a n d</td>
<td>d l</td>
<td></td>
</tr>
</tbody>
</table>

Devoicing

Surface Form: han[d]lung han[t]lich

Of the Seri rules given above, rules 5-7 all apply inside of monomorphemic words. They therefore must apply in a noncyclic stratum (as well as a cyclic stratum, perhaps). For example: R5 applies inside the monomorphemic word for ‘people’ [koŋkáak], and rules R6-7 inside the monomorphemic word for ‘person’ [kwíkæ].

**Structure Preservation**

A characteristic of some rules is that they are *structure preserving*. That is, they do not create novel feature combinations or structure. The irregular past tense suffix –*t* and the deadjectival suffix –*th* trigger Regressive Voicing Assimilation (and also Vowel Shortening). Hence, the addition of –*th* to *wide* results in a voiceless stop ([witθ]), but the addition of –*t* to *dream* (yielding *dreamt*) or –*th* to *warm* does not result in a voiceless nasal, since English does not have voiceless nasals in the underlying representations of morphemes.

Other rules are not structure preserving. For example, according to most analyses, the rule of nasal assimilation in English must precede another lexical rule which deletes the final stop in words such as *sing*. The rule of nasal assimilation is not structure preserving since it in essence creates a feature combination which does not exist underlyingly in English. Other rules which create a novel feature combination are the Flapping and Aspiration rules of English. The rules R5, R6, and R7 which apply in the Seri derivations shown above are not structure

---

10 The presentation is somewhat simplified from that given by Rubach.
preserving rules. R4 introduces the segment [ŋ], R5 introduces the segment [w̃], and R6 introduces nasalized vowels.

It was once claimed that lexical rules are necessarily structure-preserving, and that postlexical rules are not. This has been shown to be false. It was then hypothesized that cyclic rules are structure-preserving, and that noncyclic rules are not. This may be true. Myers 1991 presents another view on the relationship between rules and structure preservation, a view that is weaker but better supported empirically. He suggests that there is not one point, or stratum, in the phonology where all structure preservation is ‘turned off’. Instead, structure preservation is modularized such that a particular constraint of the phonology may be relaxed at one point in the phonology and that another constraint may be relaxed at another point. Most importantly, yet another constraint may never be relaxed, and hence even postlexical rules might obey some aspects of structure preservation.

Summary

In many cases, the formulation of a rule may be simplified (or even made possible at all) by stipulating the level(s) at which it applies, whether it applies cyclically or noncyclically, whether it obeys the Strict Cycle Condition or not, and whether it obeys Structure Preservation or not.

Perhaps we know that if a rule tests positive for one of these characteristics we also know that it will test positive for all of them. Various versions of Lexical Phonology have attempted to make them very closely related to each other. However, so many claims of Lexical Phonology have been weakened in recent years, it is not clear that there is truly any theory left from which to make any predictions.

References
Chamicuro syllable types (Peru)

<table>
<thead>
<tr>
<th>Type</th>
<th>Word</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV</td>
<td>pa.la.ka</td>
<td>‘one’</td>
</tr>
<tr>
<td>CVC</td>
<td>ŭuʔ.na</td>
<td>‘beard’</td>
</tr>
<tr>
<td></td>
<td>yel.na</td>
<td>‘man; husband’</td>
</tr>
<tr>
<td>V</td>
<td>a.peh.ta</td>
<td>‘sardine’</td>
</tr>
<tr>
<td>CCV</td>
<td>pla.wa</td>
<td>‘long’</td>
</tr>
<tr>
<td>VC</td>
<td>ih.ki</td>
<td>‘seed’</td>
</tr>
<tr>
<td></td>
<td>ay.no</td>
<td>‘mosquito’</td>
</tr>
<tr>
<td>CCVC</td>
<td>pčah.to.ki</td>
<td>‘wild, savage, fierce’</td>
</tr>
<tr>
<td></td>
<td>syek.puč.le</td>
<td>‘pot-bellied’</td>
</tr>
<tr>
<td>CV:</td>
<td>če:.wa</td>
<td>‘red’</td>
</tr>
<tr>
<td>CCCV</td>
<td>pkwa.či</td>
<td>‘cultivated field’</td>
</tr>
<tr>
<td>V:</td>
<td>i:.la</td>
<td>‘blood’</td>
</tr>
<tr>
<td>CCCVC</td>
<td>čkwaʔ.ti</td>
<td>‘guan bird’</td>
</tr>
</tbody>
</table>

source:

Berber homework (exercise 6.6)

Your written homework to turn in on Day 15 is exercise 6.6 in the Kenstowicz text. As the instructions there indicate, it would be helpful for you to first review the discussion of this language in section 6.7 (pp. 278-80). Recall that capital /U/ stands for either the vowel [u] or the corresponding glided [w]. An open circle under a segment indicates that it is syllabic. In other words, it is functioning as the nucleus of its syllable. For part A, give a derivation of the syllabification of the two forms /ra-t-lU-t/ ‘you will be born’ and /ra-t-rgl-t/ ‘you will lock’. Remember that the Obligatory Onset Condition is in effect, except word-initially. Follow example (46) on p. 280. Also, as the book indicates, the final suffix /-t/ can be treated as extrasyllabic, meaning that it is “invisible” to these rules and therefore not parsable until the very last step of the derivation (coda adjunction). But other word-final consonants (such as those in part B) should be fully incorporated into the analysis at all eligible stages.

For part B, give an analogous parsing showing the derivations of the following four ‘perfect’ forms in the left column:

/zlf/ ‘singe’
/knd/ ‘dupe’
/zdm/ ‘gather firewood’
/ršq/ ‘be happy’

Then use the corresponding phonetic representations to explain which consonants get geminated to form the ‘imperfect’. Don’t worry about writing a formal rule of gemination. Instead, state in prose any generalizations that you notice. There are two possible ways to account for which consonant gets geminated (in prose). See if you can discover both of them.
A typical consonant inventory from a hypothetical language:

- p, t, k
- b, d, g
- f, s, x
- m, n, l, r
- w, j

- Discuss the typical definitions of sonority.
- Some of the earlier attempts focused on the notion of openness / degree of “stricture.”
- However, this runs into problems when we consider fricatives vs. nasals with respect to the feature [continuant].

The classical model defined the feature [sonorant] in terms of (the possibility for) “spontaneous voicing.”
- However, this too is problematical because they also considered [?] and [h] to be [+sonorant].
- Perhaps the best definition which has been given in articulatory terms is the inverse of the degree of build up of air pressure in the mouth behind the point of constriction.
- However, the division between voiced fricatives and nasals is somewhat arbitrary; we need more concrete criteria in making a distinction such as this.
- Other definitions have been proposed along acoustic lines:
  - loudness
  - intensity
  - energy
  - as well as in auditory terms as inherent perceptual prominence.

Some linguists have also proposed phonological scales based on the notion of relative strength, sort of the inverse of sonority.
- So perhaps it is best to think of sonority as not just a binary +/- distinction but rather as a relative point along a continuous scale.

- low vowels 17
- mid peripheral vowels (not a) 16
- high peripheral vowels (not i) 15
- mid interior vowels (i) 14
- high interior vowels (i) 13
- glides 12
- rhotic approximants 11
- flaps 10
- laterals 9
- trills 8
- nasals 7
- voiced fricatives 6
- voiced affricates 5
- voiceless fricatives 3
- voiceless affricates 2
- voiceless stops 1

Now what significance does sonority have for phonological analyses?
- The Sonority Sequencing Principle (SSP) can be defined in three analogous ways:
  - Within any given syllable, there can be one, and only one, peak of sonority.
  - Every peak of sonority must correspond to a distinct syllable.
  - Within the onsets of syllables, sonority must rise, and within the codas of syllables, sonority must fall or descend.

Work through the Serbo-Croatian problem, on a separate handout.
- Focus on the alternation between [a] and Ø.
- When we have an alternation between a certain vowel and Ø, it is usually going to be a case of ephenthesis.
- The alternative would be syncope in the environment VC___CV, such as in the word family.
- However, since syncope leads to more complex syllable structure (closed syllables), it is less natural than ephenthesis, since the latter normally leads to more simple and preferred syllable structures.

vowel *
glide *
liquid *
nasal *
fricative *
stop *

dobr
pust
So here we have a case of Stray Epenthesis, and for this language the default vowel is [a] (comment on the application of Redundancy Rules at this point).

Stray or “unlicensed” consonants are dealt with in potentially one of four ways:

1. They might become phonetically syllabic, such as in the word *prism* (give the corresponding grid).

2. Stray Epenthesis — either before or after the stray consonant:

3. Stray Erasure — automatically ordered last in the list of rules; a universal mechanism rather than being language-specific; a default or “mopping up” type of operation.


So the SSP is a universal option with the language-specific parameters on/off.

The SSP can be applied differently to onsets and codas, and/or it can be violated only by certain segments, the most frequent one being /s/.

As an example, consider the sonority grid of the English word *straps*.

For reasons such as these, some phonologists classify /s/ as being more sonorous than all of the voiced fricatives.

As Latin evolved into Spanish, the SSP became activated:

- skola > escuela ‘school’
- speculu > espejo ‘mirror’
- Stephanus > Esteban ‘Stephen’

The Sonority Dispersion Principle says that in onset position of the syllable, we prefer a segment to be as low in sonority as possible (a voiceless stop). Oral glides like /w/ are the least preferred onset segments.

At the end of a syllable we prefer a segment to be as high in sonority as possible (a low vowel like /a/), all else being equal. So the phonologically most perfect or unmarked syllable would be something like /ta/ or /ka/ or /ta/.
<table>
<thead>
<tr>
<th>masculine</th>
<th>feminine</th>
<th>neuter</th>
<th>plural</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>mlád</td>
<td>mladá</td>
<td>mladó</td>
<td>mladí</td>
<td>‘young’</td>
</tr>
<tr>
<td>púst</td>
<td>pustá</td>
<td>pustó</td>
<td>pustí</td>
<td>‘empty’</td>
</tr>
<tr>
<td>zelén</td>
<td>zelená</td>
<td>zelenó</td>
<td>zelení</td>
<td>‘green’</td>
</tr>
<tr>
<td>dóbar</td>
<td>dobrá</td>
<td>dobró</td>
<td>dobrí</td>
<td>‘good’</td>
</tr>
<tr>
<td>jásan</td>
<td>jasná</td>
<td>jasnó</td>
<td>jasní</td>
<td>‘clear’</td>
</tr>
<tr>
<td>čést</td>
<td>čestá</td>
<td>čestó</td>
<td>čestí</td>
<td>‘frequent’</td>
</tr>
</tbody>
</table>

Sources of data:


**Universal hierarchy of relative sonority**

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>low vowels</td>
<td>17</td>
</tr>
<tr>
<td>mid peripheral vowels (not (\text{ə}))</td>
<td>16</td>
</tr>
<tr>
<td>high peripheral vowels (not (\text{i}))</td>
<td>15</td>
</tr>
<tr>
<td>mid interior vowels ((\text{ə}))</td>
<td>14</td>
</tr>
<tr>
<td>high interior vowels ((\text{i}))</td>
<td>13</td>
</tr>
<tr>
<td>glides</td>
<td>12</td>
</tr>
<tr>
<td>rhotic approximants ((\text{ɻ}))</td>
<td>11</td>
</tr>
<tr>
<td>flaps</td>
<td>10</td>
</tr>
<tr>
<td>laterals</td>
<td>9</td>
</tr>
<tr>
<td>trills</td>
<td>8</td>
</tr>
<tr>
<td>nasals</td>
<td>7</td>
</tr>
<tr>
<td>voiced fricatives</td>
<td>6</td>
</tr>
<tr>
<td>voiced affricates</td>
<td>5</td>
</tr>
<tr>
<td>voiced stops</td>
<td>4</td>
</tr>
<tr>
<td>voiceless fricatives</td>
<td>3</td>
</tr>
<tr>
<td>voiceless affricates</td>
<td>2</td>
</tr>
<tr>
<td>voiceless stops</td>
<td>1</td>
</tr>
</tbody>
</table>

Source:

Some important principles of autosegmental phonology

The term autosegmental phonology was invented by John Goldsmith and is the title of his 1976 doctoral dissertation at MIT (Massachusetts Institute of Technology).

His Well-Formedness Condition (WFC) has three clauses:

1. Every tone must be associated with at least one vowel (or tone-bearing unit).
2. Every vowel must be associated with at least one tone.
3. Association lines may not cross.

To resolve potential ambiguities of representation, he also proposes the Tone Language Principle: given more than one way to satisfy the Well-Formedness Condition, in the default or unmarked case, associate tones with tone-bearing units one-to-one and from left-to-right.

In his dissertation Goldsmith identifies five arguments / motivations in support of autosegmental theory:

1. the behavior of contour tones: in most African languages, phonetic contours tend to be preferentially produced at the ends of words, due to the WFC in combination with the Tone Language Principle. Also, falling tones often pattern as though they begin with a high tone and end with a low tone, in terms of their effects on neighboring tones (assimilation via spreading).

2. tonal stability: a phenomenon whereby tones tend to persist (persevere) even when the segmental anchor (tone-bearing unit) which they are originally associated with deletes or is modified. See the Margi data in (23) on page 321 of the textbook for an example of this.

3. floating tones: a morpheme which consists entirely of tonal specifications (features) in terms of its underlying representation, without any segmental make-up.

   Igbo docking: /ʼò gbùò éghú/ → [ò gbùò éghú] ‘lest he kill the leopard’

4. word-level tonal melodies: some languages exhibit a restricted or limited number of word-level tonal melodies, which expand (spread out) or contract together depending on how many syllables are in the word that they are associating with. See the Mende data in exercise 7.2 on page 386 for an illustration of this.

5. automatic spreading: bidirectional assimilation which does not require language-specific rules but rather follows directly from the geometry of autosegmental representations. An example is Guarani nasal harmony and postoralization:
(a) oral stem: \[ ^{\text{nd}o + \text{ro} + \text{haihú} + \text{i}} \] ‘I don’t love you.’

(b) oral stem with a nasal in it: \[ ^{\text{nõ} + \text{ãõ} + \text{ẽndú} + \text{i}} \] ‘I don’t hear you.’

(c) nasal stem: \[ ^{\text{nõ} + \text{ãõ} + \text{núpã} + \text{i}} \] ‘I don’t whip you.’

Obligatory Contour Principle: At the melodic level, adjacent identical elements (autosegments) are prohibited.

The *melodic* level specifically excludes units on the timing tier (C’s, V’s, X’s, moras, etc.). These are allowed to repeat. The first work to propose a constraint of this sort is Will Leben’s (1973) MIT dissertation on suprasegmental phonology. The name “OCP” dates from Goldsmith (1976). Since then the scope of the OCP has been expanded to include non-tonal phenomena as well.

Universal Association Convention: Associate tones with tone-bearing units {left-to-right, right-to-left} and {one-to-one, many-to-one}. This is a universal principle with language-specific parameters. The unmarked or default options are underlined. The UAC replaces the Tone Language Principle since there is no need for both of them.
Tone Phenomena Common to African Languages
Keith Snider

The present work provides an overview of the following tonal phenomena:
1. Tone melodies
2. Tone spreading
3. Floating tone morphemes
4. Toneless morphemes
5. Automatic downstep
6. Nonautomatic downstep
7. Consonant/tone interaction
8. “Polar” tones
9. Nonreplacive grammatical tone
10. Replacive grammatical tone
11. Boundary tones
12. Tone shift
13. Super Hi’s

1. Tone Melodies

The phoneme of tone is the complete melody associated with a particular morpheme, not an individual tone in the melody. Consider the following Mende data (Leben 1978).

<table>
<thead>
<tr>
<th></th>
<th>One-Syllable</th>
<th>Two-Syllable</th>
<th>Three-Syllable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hi</td>
<td>kó 'war'</td>
<td>pélé 'house'</td>
<td>háwámá 'waistline'</td>
</tr>
<tr>
<td>Lo</td>
<td>kpà 'debt'</td>
<td>bêlê 'trousers'</td>
<td>kpàkâli 'tripod chair'</td>
</tr>
<tr>
<td>Hi Lo</td>
<td>mbû 'owl'</td>
<td>ngílà 'dog'</td>
<td>félâmá 'junction'</td>
</tr>
<tr>
<td>Lo Hi</td>
<td>mbá 'rice'</td>
<td>fàndé 'cotton'</td>
<td>ndàvúlá 'sling'</td>
</tr>
<tr>
<td>Lo Hi Lo</td>
<td>mbâ 'companion'</td>
<td>nỳâhâ 'woman'</td>
<td>níkílî 'groundnut'</td>
</tr>
</tbody>
</table>

The display below shows a number of the options present-day Niger-Congo languages use to resolve the problem of fitting, or associating, the original PNC melody to the shorter stems.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>H *cvcv</td>
<td>cv</td>
<td>cv</td>
<td>cv</td>
<td>cv</td>
<td>cv</td>
</tr>
<tr>
<td>L *cvcv</td>
<td>cv</td>
<td>cv</td>
<td>cv</td>
<td>cv</td>
<td>cv</td>
</tr>
<tr>
<td>LH *cvcv</td>
<td>cv</td>
<td>cv</td>
<td>cv</td>
<td>cv</td>
<td>cv</td>
</tr>
<tr>
<td>HL *cvcv</td>
<td>cv</td>
<td>cv</td>
<td>cv</td>
<td>cv</td>
<td>cv</td>
</tr>
</tbody>
</table>
2. Tone Spreading

One of the most common phenomena in African languages is tone spreading. When this happens, the tone of one tone-bearing unit (TBU) “spreads” over onto one or more adjacent TBUs. Often when this happens, the original tone of the recipient TBU is delinked and replaced completely by the first tone. Sometimes however, the second tone is not delinked. Instead the first tone spreads onto the adjacent TBU and joins the second tone to create a contour tone. In the first example below, the Hi tone of the associative marker (AM) spreads rightwards onto the plural prefix of the following word and delinks the original Lo tone from that TBU. In the second example, the Lo tone of the plural prefix spreads rightwards onto the root for ‘thief.’ In this case however, it does not delink the original Hi tone of the recipient TBU, but rather joins with it to create a rising contour.

Yemba (also known as Bamileke-Dschang) data taken from Hyman 1985:50

àsàŋ á m̥–ndzw̥ → [àsàŋ á m̥ndzw̥] ‘tail of leopards’
tail AM PL–leopard

èɓ̥è m̥–ts̥ŋ → [èɓ̥è m̥ts̥ŋ] ‘chief of thieves’
chief AM PL–thief

3. Floating Tone Morphemes

Many morphemes have historically lost their segmental component and consist solely of a “floating” melody. Look at these floating noun class prefixes in Mada (data courtesy of Norman Price).

\[
\begin{array}{|c|c|c|}
\hline
\text{Group A} & \text{Singular (L)} & \text{Plural (H)} & \text{Diminutive (Sing.)} \\
\hline
\text{[`mbú]} & [mbú] & [`mbú] & [fé[`mb ú]] \rightarrow [vém bú] 'jar' \\
\text{[`kí]} & [kí] & [`kí] & [fé[`kí]] \rightarrow [vékí] \\
\text{[`gar]} & [gár] & [`gár] & [fé[`gar]] \rightarrow [végár] 'ant' \\
\hline
\end{array}
\]

\[
\begin{array}{|c|c|c|}
\hline
\text{Group B} & \text{Singular (H)} & \text{Plural m̥–} & \text{Diminutive (Sing.)} \\
\hline
\text{[`gén]} & [gén] [m̥[gén]] & \rightarrow [m̥gén] & [fé[`gén]] \rightarrow [fégén] 'slave' \\
\text{[`cùn]} & [cùn] [m̥[cùn]] & \rightarrow [m̥cùn] & [fé[`cùn]] \rightarrow [fécùn] 'chief' \\
\hline
\end{array}
\]
4. Toneless Morphemes

Many morphemes are simply toneless, taking their tone from an adjacent TBU, or else receiving a (usually Lo) default tone. Some examples of toneless morphemes in Kenyang (personal data) appear below. Note also the Mada example of gar ‘ant’ from the above discussion on floating tone morphemes.

**Iterative**
bá–māy–pā → [bá mày pá] ‘they spit from time to time’
3P–ITER–spit
bá–māy–kō → [bá mày kō] ‘they walk from time to time’
3P–ITER–walk
bá–māy–te → [bá mày tē] ‘they stand from time to time’
3P–ITER–stand
bá–māy–nisī → [bá mày nìsì] ‘they refuse from time to time’
3P–ITER–refuse

**Hortative**
bá–mī–pā → [mā mī pá] ‘they should spit’
3P–HORT–spit
bá–mī–kō → [mā mì kō] ‘they should walk’ **COMPARE THIS EXAMPLE**
3P–HORT–walk
bá–mī–tē → [mā mì tē] ‘they should stand’ **WITH THIS EXAMPLE**
3P–HORT–stand
bá–mī–nisī → [mā mì nìsì] ‘they should refuse’
3P–HORT–refuse

**Imperfective**
bá–pā → [bá pā] ‘they are spitting’
3P–IMPF–spit
bá–kō → [bá kō] ‘they are walking’
3P– IMPF–walk
bá–tē → [bá tē] ‘they are standing’
3P– IMPF–stand
bá–nisī → [mā nìsì] ‘they are refusing’
3P– IMPF–refuse

5. Automatic Downstep

Downstep is of two varieties: automatic and nonautomatic. A language has automatic downstep when the following conditions are met: a) the Lo of a Hi Lo sequence is realized on a lower register than the preceding Hi, and b) the Hi of a Lo Hi sequence is realized on the same register as the preceding Lo. The downstep effect is "terrace-like," so that the tonal register descends in a series of steps, and once lowered, is never again raised within the same
phonological phrase. It is also the case that all adjacent like tones are realized at the same level. Theoretically, the number of downsteps in any given utterance is unlimited. Automatic downstep is illustrated by the following Chumburung example.

\[
\text{ádópú jônò kíŋápú kiyé?}
\]

'farmer's dog's breast's flesh'

6. Nonautomatic Downstep

Nonautomatic downstep, usually indicated with either a raised exclamation mark or else a down arrow (used in this work), differs from automatic downstep only in that the Lo is unassociated, or floating, in nonautomatic downstep. Floating Lo tones often occur as the result of a process in which a Lo tone is delinked from its segmental tone-bearing unit by the spreading of an adjacent non-Lo tone. The following Chumburung example illustrates this.

\[
\text{náátfí kísíbó} \rightarrow \text{[náátfí kí'síbó]} \text{'cow's ear'} \text{(Chumburung)}
\]

Floating Lo tones also often occur as the result of a historical process in which a Lo tone’s segmental tone-bearing unit is deleted historically. In Chumburung, words that have undergone apocope (loss of a final segment or segments) are realized with a glottal stop utterance finally. Although the Chumburung word for ‘kapok trees’ has historically lost a final Lo-toned TBU, the Lo tone itself has not been lost, and its presence is confirmed when it causes following Hi tones to be downstepped.

\[
\begin{align*}
\text{Chumburung} & \quad \text{à–kiré? ‘kapok trees’} & \text{àkiré ɪkúdu ‘ten kapok trees’} \\
\text{Gonja} & \quad \text{j–kilíyè ‘kapok trees’}
\end{align*}
\]

In the Kenyang example (repeated from above), the segmental component of the PRES marker has historically been deleted, and only its Lo tone is left. Although it’s historical presence has not yet been reconstructed, its presence today is nevertheless confirmed when it causes following Hi tones to be downstepped.

\[
\text{bá– ‘pá} \rightarrow \text{[bá ɪpá] ‘they are spitting’ (Kenyang)}
\]

3P–PRES–spit

7. Consonant/Tone Interaction

Kera (data from Pearce 1999), a Chadic language spoken in Chad, is a tonal language with three surface tone levels, but only two underlying tone levels. Consonants divide into three classes, depending upon how they influence the tone system:

a) depressors, which cause underlyingly toneless morphemes to be realized with Lo tone
b) raisers, which cause underlyingly Lo-toned morphemes to be realized with Mid tone
c) neutrals, which have no effect on the tone system.

Depressor  \( b \ d \ dʒ \ g \ v \ z \ h \)
Raiser  \( p \ t \ tʃ \ k \ f \ s \ θ \ d^r \)
Neutral  \( m \ n \ η \ l \ y \ w \)

Nouns have underlying melodies of L, LH, HL, and H; and verbs are toneless. Words that
have single tone melodies have both syllables associated to single tones.

**Nouns**
Disyllabic nouns in Kera are realized with seven surface melodies: LL, LH, HL, HH, MM, MH, and HM. Depressor and neutral consonants have no affect on these underlying
melodies, as may be seen in the first set of data. Raiser consonants raise the Lo part of any
underlying melody to surface Mid tone.

The first consonant of these words is not a raiser consonant.

<table>
<thead>
<tr>
<th>Underlying</th>
<th>Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL</td>
<td>LL</td>
</tr>
<tr>
<td>bɔgɔr</td>
<td>‘antelope’</td>
</tr>
<tr>
<td>dɔmɔl</td>
<td>‘drum’</td>
</tr>
<tr>
<td>dʒàaŋgà</td>
<td>‘stool’</td>
</tr>
<tr>
<td>gàrdà</td>
<td>‘millet’</td>
</tr>
<tr>
<td>LH</td>
<td>LH</td>
</tr>
<tr>
<td>bisíl</td>
<td>‘type of tree’</td>
</tr>
<tr>
<td>gùugúr</td>
<td>‘chicken’</td>
</tr>
<tr>
<td>vèdè</td>
<td>‘appearance’</td>
</tr>
<tr>
<td>zònùl</td>
<td>‘soap’</td>
</tr>
<tr>
<td>HL</td>
<td>HL</td>
</tr>
<tr>
<td>ábày</td>
<td>‘spirit sacrifice’</td>
</tr>
<tr>
<td>gègèl</td>
<td>‘basket’</td>
</tr>
<tr>
<td>zògòy</td>
<td>‘exorcism’</td>
</tr>
<tr>
<td>HH</td>
<td>HH</td>
</tr>
<tr>
<td>wàlkà</td>
<td>‘fear’</td>
</tr>
<tr>
<td>lèsé</td>
<td>‘suffering’</td>
</tr>
<tr>
<td>lòoné</td>
<td>‘big jug’</td>
</tr>
</tbody>
</table>
The first consonant of these words is a raiser consonant.

<table>
<thead>
<tr>
<th>Underlying</th>
<th>Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL</td>
<td>MM</td>
</tr>
<tr>
<td>pātatāl</td>
<td>‘needle’</td>
</tr>
<tr>
<td>tārnā</td>
<td>‘daughter’</td>
</tr>
<tr>
<td>kāmpā</td>
<td>‘leg’</td>
</tr>
<tr>
<td>LH</td>
<td>MH</td>
</tr>
<tr>
<td>kāskō</td>
<td>‘bird’</td>
</tr>
<tr>
<td>sūpō</td>
<td>‘yeast’</td>
</tr>
<tr>
<td>tētkér</td>
<td>‘tomb’</td>
</tr>
<tr>
<td>HL</td>
<td>HM</td>
</tr>
<tr>
<td>pārdāŋ</td>
<td>‘foreigners’</td>
</tr>
<tr>
<td>fārtā</td>
<td>‘type of skirt’</td>
</tr>
<tr>
<td>tákrā</td>
<td>‘porridge’</td>
</tr>
<tr>
<td>HH</td>
<td>HH</td>
</tr>
<tr>
<td>pārkí</td>
<td>‘mountain’</td>
</tr>
<tr>
<td>títí</td>
<td>‘corpse’</td>
</tr>
<tr>
<td>tfűŋkúy</td>
<td>‘spear’</td>
</tr>
</tbody>
</table>

| LH          | MM      |
| kāľōý      | ‘type of bird’ |
| sūkāl      | ‘fence’  |
| tōsūsū     | ‘type of tree’ |
| stēm       |          |
| HL          | HM      |
| kāsko@     | ‘bird’  |
| køl∫o@y    | ‘sesame’ |
| s“ip@      | ‘yeast’ |
| saNka@     | ‘type of tree’ |
| teNtek@    | ‘tomb’  |
| HH          | HH      |
| p“irk@     | ‘mountain’ |
| k“ift@     | ‘moon’  |
| s“ip@      | ‘yeast’ |
| saNge@     | ‘mosquito net’ |

**Verbs**

Disyllabic verbs in Kera are realized with three surface melodies, LL, LH, and HH. Once the consonants are known, these melodies are completely predictable:

- a) LL – first consonant only is a depressor consonant
- b) LH – both consonants are depressor consonants
- c) HH – no depressor consonant is present.

Kera verbs are underlingly toneless, with the default tone being Hi. If the word begins with a single depressor consonant, the surface melody will be realized as LL. If both consonants are depressor consonants, the melody will be LH. I believe the failure of this melody to be LL is because there is a strategy to repair what the OCP disallows, viz., sequences of adjacent identical tones. This is similar to Meeussen’s Rule for Bantu, which causes sequences of HH to be realized as HL. (Other sequences of adjacent identical surface tones in Kera should be considered single tones associated to more than one tone-bearing unit.) Any verb that does not contain a depressor consonant is realized with the default Hi tone.

These words all contain a single depressor consonant in initial position.

<table>
<thead>
<tr>
<th>Underlying</th>
<th>Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø</td>
<td>LL</td>
</tr>
<tr>
<td>bêlê</td>
<td>‘to love’</td>
</tr>
<tr>
<td>dêfê</td>
<td>‘to prepare’</td>
</tr>
<tr>
<td>dzênê</td>
<td>‘to break’</td>
</tr>
<tr>
<td>Ø</td>
<td>LH</td>
</tr>
<tr>
<td>bâadê</td>
<td>‘to wash’</td>
</tr>
<tr>
<td>dzêbrê</td>
<td>‘to listen’</td>
</tr>
<tr>
<td>gêlêgé</td>
<td>‘to tickle’</td>
</tr>
</tbody>
</table>

These words all contain two depressor consonants.

<table>
<thead>
<tr>
<th>Underlying</th>
<th>Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø</td>
<td>LH</td>
</tr>
<tr>
<td>hârgî</td>
<td>‘to dance’</td>
</tr>
<tr>
<td>vâögî</td>
<td>‘to pardon’</td>
</tr>
<tr>
<td>zâldê</td>
<td>‘to hit’</td>
</tr>
</tbody>
</table>
These words all begin with any consonant other than a depressor consonant.

<table>
<thead>
<tr>
<th>Underlying</th>
<th>Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø</td>
<td>HH</td>
</tr>
<tr>
<td>dôkê</td>
<td>HH</td>
</tr>
<tr>
<td>tʃêwê</td>
<td>HH</td>
</tr>
<tr>
<td>kôsê</td>
<td>HH</td>
</tr>
<tr>
<td>bêlé</td>
<td>‘to nail’</td>
</tr>
<tr>
<td>lôdê</td>
<td>‘to dampen’</td>
</tr>
<tr>
<td>mêlé</td>
<td>‘to place’</td>
</tr>
<tr>
<td>nâakê</td>
<td>‘to disintegrate’</td>
</tr>
<tr>
<td>sêtê</td>
<td>‘to wipe’</td>
</tr>
</tbody>
</table>

8. “Polar” Tones

Polar tones are tones whose surface realization is always opposite to that of an adjacent tone. In Konni, a Gur language spoken in northern Ghana, the plural suffix of noun class 1 is –a, with a tone that is opposite to that of the preceding noun stem (data from Cahill 1998). Segmentally, the suffix is phonetically realized as [e] with +ATR vowels, and as [a] with –ATR vowels.

Polar tones in Chumburung, a Guang language spoken in Ghana, are slightly more complicated. Noun class prefixes in Chumburung behave identically, regardless of which noun class they belong to. The surface realization of the vowel of the kI− prefix alternates between, i, I, u, and ū and is conditioned by root-controlled vowel harmony constraints. If we assume that the TBUs of nouns with surface Lo tones are underlyingly toneless, then it is possible to analyze the prefix tone as a polar tone. Consider these examples.

<table>
<thead>
<tr>
<th>Stem</th>
<th>Singular −i</th>
<th>Plural −a</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>tân</td>
<td>tâŋ</td>
<td>tâná</td>
<td>stone</td>
</tr>
<tr>
<td>bîs</td>
<td>bîsîŋ</td>
<td>bîsâ</td>
<td>breast</td>
</tr>
<tr>
<td>sî</td>
<td>sîŋ</td>
<td>sfâ</td>
<td>fish</td>
</tr>
<tr>
<td>tíq</td>
<td>tíqîŋ</td>
<td>tíqê</td>
<td>house</td>
</tr>
</tbody>
</table>

Polar tones can be analyzed as the result of a variation of “Meeussen’s Rule” for Bantu languages. For the contexts in which Meeussen’s Rule applies, a Hi tone that follows another Hi tone is phonetically realized as a Lo tone. With today’s perspective, one way to analyze polar tones is to say that they are the result of two processes, i.e., a) in certain contexts a Hi tone is deleted following or preceding another Hi tone, and b) a toneless TBU receives a Lo tone by default.

HH → HØ or HH → ØH
Ø → L
9. Nonreplacive Grammatical Tone

In Kenyang, the Perfective is the least marked form of the verb and consists of the subject marker followed by the verb. There are no underlying floating tones associated with this construction and all underlying tones are realized in the surface forms. There is a rule of Hi-Tone Spread that spreads the Hi tone of the subject marker onto a following Lo-toned verb like kɔ̣, thereby resulting in its being realized as kɔ̣, with a Hi-falling tone.

The Imperfective form of the verb in Kenyang consists of a floating Lo prefix that causes a following Hi tone to be downstepped and which does not affect following Lo tones. The floating Lo does, however, prevent a preceding Hi tone from spreading onto a Lo-toned verb. This is why kɔ̣ is not realized with a Hi-falling tone, as it is in the Perfective.

\[
\begin{align*}
\text{Perfective} & \quad \text{Imperfective} \\
\text{bá–pá} & \rightarrow [bá pá] & \text{bá–'pá} & \rightarrow [bá 'pá] \\
3P–spit & \quad \text{‘they spat’} & 3P–IMPF–spit & \quad \text{‘they are spitting’} \\
\text{bá–kò} & \rightarrow [bá kò] & \text{bá–'kò} & \rightarrow [bá kò] \\
3P–walk & \quad \text{‘they walked’} & 3P–IMPF–walk & \quad \text{‘they are walking’}
\end{align*}
\]

In Kako, present progressive forms of the verb retain the underlying tone of the verb. While what we can call the “Subjunctive 1” forms also retain the underlying tone of the verb, in addition the verb is preceded by a floating Hi and followed by a floating Lo tone. The preceding floating Hi doesn’t affect Hi-toned verbs like wó, but it spreads onto Lo-toned verbs like bèg causing them to be realized with a Hi-falling tone ‘bèg. The following floating Lo tone, however, has a “raising” effect on Hi-toned verbs causing wó to be realized as ‘wó. This Lo does not affect Lo-toned verbs like bèg, however. The fact that the Hi-falling tone of bèg is raised is because the underlying Lo of the verb causes the Hi part of the fall to be raised.

\[
\begin{align*}
\text{Present Progressive} & \quad \text{Subjunctive 1} \\
\text{Underlying verb tone} & \quad \text{Underlying verb tone} \\
\text{Hi Verb} & \quad \text{H(L)} \quad \text{H(L)} \quad \text{H(L)} \quad \text{H(L)} \quad \text{H(L)} \quad \text{H(L)} \\
mbà 'kè wó só & \quad \text{'nè mbà 'wó 'só} \\
civet Prog. kill friend & \quad \text{civet kill friend} \\
\text{'civet is killing friend'} & \quad \text{'so that civet kills friend'} \\
\text{Lo Verb} & \quad \text{H(L)} \quad \text{H(L)} \quad \text{H(L)} \quad \text{H(L)} \quad \text{H(L)} \quad \text{H(L)} \\
mbà 'kè bènè só & \quad \text{'nè mbà 'bènè 'só} \\
civet Prog. see friend & \quad \text{civet see friend} \\
\text{'civet is seeing friend'} & \quad \text{'so that civet sees friend'}
\end{align*}
\]
10. Replacive Grammatical Tone

In the past tense forms of Jukun (Welmers 1973:132), the pronoun is realized with its inherent underlying tone. In the hortative mood, however, the inherent tone of the pronoun is "replaced" by a Hi tone, which is the sole marker of the hortative construction.

<table>
<thead>
<tr>
<th>Past</th>
<th>Hortative</th>
</tr>
</thead>
<tbody>
<tr>
<td>m̀ yā</td>
<td>'I went'</td>
</tr>
<tr>
<td>ü yā</td>
<td>'you (sg.) went'</td>
</tr>
<tr>
<td>kù yā</td>
<td>'he went'</td>
</tr>
<tr>
<td>î yā</td>
<td>'we went'</td>
</tr>
<tr>
<td>ǹ yā</td>
<td>'you (pl.) went'</td>
</tr>
<tr>
<td>bȅ yā</td>
<td>'they went'</td>
</tr>
<tr>
<td>nǹ yā</td>
<td>'you (pl.) went'</td>
</tr>
<tr>
<td>bȅ yā</td>
<td>'they should go'</td>
</tr>
</tbody>
</table>

In Kako (personal data), many grammatical distinctions are indicated solely by tonal differences. While present progressive forms of the verb retain the underlying tone of the verb, what we can call the “Subjunctive 2” form (for want of a better term) replaces the underlying tone of the verb with a Lo tone. This Lo tone does not interact in any way with the underlying tone of the verb, but replaces it completely.

<table>
<thead>
<tr>
<th>Present Progressive</th>
<th>Subjunctive 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underlying verb tone</td>
<td>Replacive L tone</td>
</tr>
<tr>
<td>Hi Verb</td>
<td></td>
</tr>
<tr>
<td>mbà 'kè wò sò</td>
<td>'nè mbà 'kè wò sò</td>
</tr>
<tr>
<td>L H(L) H H</td>
<td>H (L) L H(L) H H</td>
</tr>
<tr>
<td>civet Prog. kill friend</td>
<td>Subj. civet Prog. kill friend</td>
</tr>
<tr>
<td>'civet is killing friend'</td>
<td>'so that civet will kill friend'</td>
</tr>
<tr>
<td>Lo Verb</td>
<td></td>
</tr>
<tr>
<td>mbà 'kè bèŋ sò</td>
<td>'nè mbà 'kè bèŋ sò</td>
</tr>
<tr>
<td>L H(L) L H</td>
<td>H (L) L H(L) L H</td>
</tr>
<tr>
<td>civet Prog. see friend</td>
<td>Subj. civet Prog. see friend</td>
</tr>
<tr>
<td>'civet is seeing friend'</td>
<td>'so that civet will see friend'</td>
</tr>
</tbody>
</table>

11. Boundary Tones

Although the concept of boundary tones is relatively new to linguists, it is not a particularly surprising phenomenon, given what is already known about floating tones and clitics. One normally thinks of floating tones as being associated with certain words (i.e., certain words are known to begin or end in floating tones). One also thinks of floating tones as sole morphemes in their own right, morphemes that historically have lost their segmental attributes and consist solely of floating tones. In African languages, tonal morphemes often serve as noun class markers and tense/aspect markers. With respect to clitics, clitics are particles that attach themselves to no particular class of morphemes or words, but rather are found at the edges, or boundaries, of certain syntactic constituents, regardless of how long those constituents may be. One can think of boundary tones as simply clitics that consist solely of floating tones. The examples below illustrate a Lo boundary tone (BT) in Bimoba.
(personal data) that is consistently assigned to the right edge of the noun phrase, regardless of the length of the phrase.

**Bimoba (Ghana)**

a. `jɔ–ɔ` → [joɔ]  
   man–NC–BT ‘man’

b. `jɔ–ɔ peɛ–n` → [joɔ peen]  
   man–NC white–NC–BT ‘white man’

c. `jɔ–ɔ peɛ–n` `jɔ–ɔ peɛ–n` → [joɔ peen joɔ peen]  
   man–NC white–NC–AM man–NC white–NC–BT ‘white man’s white man’

Throughout these examples, all tones, including the floating Mid associative marker (AM) in (c), are Mid, except for the floating Lo boundary tone. This Lo tone docks onto the final syllable of the noun phrase, where it combines with, in the case of the examples above, the lexical Mid tone and is realized as a Mid-falling tone.

In Kako, there is often a floating boundary tone that occurs at the right edge of the verb stem. There is often another boundary tone that occurs at the left edge of the verb stem, between the INFL and the verb root. In this context, *stem* refers to the verb root plus the Final Vowel and any extensions (not shown here) on the verb root. The following chart sets out the main characteristics of each of the tenses in the positive. In the charts, T represents the inherent underlying tone of any given morpheme. FV stands for the Final Vowel that is characteristic of Bantu verbs.
12. Tone Shift

Noun roots in Lobala (data from Morgan 1995) are mostly disyllabic and have only two surface melodies: LL and LH. Following roots with LL surface melodies, any given associative marker has two surface realizations, H and L. This suggests that roots with LL surface melodies belong to two different underlying tone classes. We notice the same phenomenon with roots that have LH surface melodies, suggesting that these roots also belong to two different underlying tone classes. The different surface realizations of the nouns and the associative markers that follow them are best explained if we posit noun roots as having underlying melodies of LL, LH, HH, and HL, together with a rightward tone shifting rule that operates on the phrasal level. This is illustrated by the following four data sets, which are identical except for the object nouns.

<table>
<thead>
<tr>
<th>T/A/M</th>
<th>AUX</th>
<th>S.</th>
<th>INFL</th>
<th>BD</th>
<th>[[ROOT] FV]</th>
<th>BD</th>
<th>D.O.</th>
<th>BD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Past</td>
<td></td>
<td></td>
<td></td>
<td>∅</td>
<td>[[∅ ] H]</td>
<td>∅</td>
<td>T</td>
<td>xx</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[[Root] ma]</td>
<td></td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Aorist</td>
<td></td>
<td></td>
<td></td>
<td>H</td>
<td>[ ∅ ]</td>
<td>L</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[[Root] FV]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injunct.</td>
<td></td>
<td></td>
<td></td>
<td>H</td>
<td>[[ ∅ ] L]</td>
<td>L</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[[Root] FV]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future</td>
<td></td>
<td></td>
<td></td>
<td>∅</td>
<td>[ T ]</td>
<td>L</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[[Root] FV]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prog.</td>
<td></td>
<td></td>
<td></td>
<td>H</td>
<td>[ T ]</td>
<td>H</td>
<td>T</td>
<td>xx</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[[Root] FV]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subj.1</td>
<td>H L</td>
<td>T</td>
<td>xx</td>
<td>H</td>
<td>[ T ]</td>
<td>L</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[[Root] FV]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subj.2</td>
<td>H L</td>
<td>T</td>
<td>xx</td>
<td>H</td>
<td>[ ∅ ]</td>
<td>H</td>
<td>T</td>
<td>xx</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[[Root] (FV)]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Noun melody LL**

SF  nà–wèn–í mú–ŋòndò wà bàŋŋà
gloss 1S–see–PF C1–girl C1.AM 1P

Transl. I have seen our girl.

**Noun melody LH**

SF  nà–wèn–í mó–kàlè wà bàŋŋà
gloss 1S–see–PF C1–second.wife C1.AM 1P

Transl. I have seen our second wife.
13. Super Hi’s

Super Hi’s almost always (if not always) occur in the environment of Lo tones, either floating or otherwise. Sometimes only floating Lo’s cause it. In Engenni, a Hi before a Lo always results in the Hi being super Hi or “upstepped.” As we will see in the Register Tier Theory lectures, there is good reason to consider the super Hi’s to be simply “nondownstepped.” However, for our purposes here, we will simply assume Thomas’ (1974, 1978) terminology and speak of the super Hi as having been “upstepped” in the environment of a Lo tone.

Although Thomas describes Engenni, a Kwa language spoken in Nigeria, as having three levels of surface pitch, with restrictions on the top and middle levels, she analyzes the system as having only two contrasting tonemes, Lo and Hi. In addition there is what she calls “automatic upstep.”

Upstep can be described as the phonological shifting upwards of the tonal register within a phonological phrase, similar in nature to changing to a higher key in a score of music. Upstep in Engenni is predictable and results in the shifting upwards of a Hi tone whenever a Lo tone follows the Hi. Examples of this appear in (1) and (2).1 In the surface representations throughout this paper, the dotted lines represent the tonal registers, and the solid lines the tones of the utterance relative to the registers, that is, the idealized pitch tracks.

(1) a. b.

\[
\begin{align*}
\text{mì mólní wó} & \quad \text{mì mólní wó bhèè} \\
'I \text{ saw you.}' & \quad 'I \text{ did see you.}'
\end{align*}
\]

---

1All data in this article are taken from Thomas (1974, 1978). Although I have included all glosses as they are provided in the source documents, I have taken the liberty to replace certain of Thomas' phonetic symbols with their IPA equivalents. In some cases, more detail would have been desirable, but this information was not available to me. I have similarly accepted Thomas' underlying forms as provided. Although I have no reason to question their validity, at the same time I would have preferred to have been able to include more evidence to support them.
In (1a) \( w_\delta \) is realized at the same level as the Hi-toned tone-bearing units that precede it. This may be contrasted with (1b) in which a Lo tone follows \( w_\delta \). In this case, the Hi tone of \( w_\delta \) is upstepped relative to the Hi-toned TBUs that precede it.

(2) a. ómù dhémù yá
   'The house is big.'

   b. ómù dhémù yá sèmù
   'Is the house big?'

(2) is similar to (1) except that the utterance begins with Hi tone. Again, each time a Hi-toned TBU tone precedes a Lo-toned TBU, the Hi-toned TBU is upstepped relative to preceding Hi-toned TBUs. Another example appears in (3) in which the utterance begins with a Hi-toned TBU, but in this case it is not immediately followed by a Lo tone.

(3) á kpú kùrò
   'cassava'

As can be seen in (3), it is only when a Hi-toned TBU occurs immediately before a Lo tone that it is upstepped.

Upstep also occurs when the tone-bearing support for the Lo tone is deleted. “When two vowels come together at a word boundary, the first vowel together with its tone is elided” (Thomas 1974:14, 15). This may be seen in (4).

(4) a. únwóni ólíló
    → un wo nolilo  'mouth of a bottle'

    b. ó vúmù ópílópó
    → o vu mopilopo  'she will dry the pig meat'

In these examples, even though the tone-bearing support of the Lo tone in each case has been elided, upstep on the immediately preceding Hi still occurs.
References


1. [ 'tu³tu⁵ ] ‘paper’ 
2. [ 'bi³ko³ ] ‘fiesta’ 
3. [ 'ka⁴zu⁵ ] ‘will burn’ 
4. [ 'zu³u³ ] ‘straw mat’ 
5. [ 'ti⁵ka² ] ‘basket’ 
6. [ 'bi³ko⁵ ] ‘cloud’ 
7. [ 'zo³so² ] ‘metate’ 
8. [ 'zu³u⁵ ] ‘stone’ 
9. [ 'si³ni⁵ ] ‘head’ 
10. [ 'ka³zu³ ] ‘will cough’ 
11. [ 'ki³ni⁵ ] ‘pig’ 
12. [ 'xi¹ka¹ ] ‘far’ 
13. [ 'ka¹žu³ ] ‘is coughing’ 
14. [ 'ku⁵ñu³ ] ‘meat’ 
15. [ 'zu³u⁵ ] ‘ditch’ 
16. [ 'ka¹žu⁵ ] ‘is burning’ 
17. [ 'ba¹tu⁵ ] ‘belt’ 
18. [ 'na⁴ma⁵ ] ‘soap’ 
19. [ ‘sa³a¹ ] ‘thus’ 
20. [ ‘xi¹ka³ ] ‘is walking’ 
21. [ ‘ku¹ni⁵ ] ‘wants’ 
22. [ ‘žu¹tu¹ ] ‘carrying rope’ 
23. [ ‘ki³si³ ] ‘cooking pot’ 
24. [ ‘sa³a⁵ ] ‘bird’ 
25. [ ‘ža³ka² ] ‘garbage’ 
26. [ ‘ku³u³ ] ‘will be’ 
27. [ ‘ži¹ži³ ] ‘badger’ 
28. [ ‘le³xo³ ] ‘rabbit’ 
29. [ ‘ža¹a¹ ] ‘tongue’ 
30. [ ‘ti³ka³ ] ‘grasshopper’ 
31. [ ‘ku¹u³ ] ‘is’ 
32. [ ‘su³xa³ ] ‘pitch’ 
33. [ ‘lu³li¹ ] ‘little’ 
34. [ ‘ko³ko¹ ] ‘will swallow’ 
35. [ ‘xi¹te⁵ ] ‘wide’ 
36. [ ‘ni³i⁵ ] ‘salt’

Assume that 1 is the highest phonetic tone and 5 is the lowest phonetic tone.

A list of some of the factors which affect tone

1. The vowel of the syllable:
   a. The vowel /i/ (and sometimes /u/) may cause higher allotones.
   b. Nasal vowels may cause lower allotones.
   c. Breathy vowels may cause lower allotones.
   d. Long vowels may cause lower allotones of a high tone.

2. Type of syllable:
   a. A high tone may upglide or be raised in a closed syllable.
   b. A high tone may downglide in an open syllable.
   c. A high tone may be lowered in a syllable with a long vowel.

3. Adjacent consonants:
   a. Higher allotones may occur preceding a glottal stop.
   b. Higher allotones may occur following a voiceless consonant.
   c. Lower allotones may occur adjacent to a voiced obstruent.

4. Adjacent tones:
   a. A high tone may be raised preceding a low tone.
   b. A high tone may be lowered or upglide following a low tone.
   c. A low tone may downglide following a high tone.
   d. A low tone may have higher allotones between mid and/or high tones.
   e. An upglided tone in an underlying form may become a level tone in a phonetic form.

5. Position within the word or phrase:
   a. A low tone often downglides in a final (prepause) syllable. (High tones seldom downglide in this environment.)
   b. A sequence of high tones may downdrift.
   c. A sequence of low tones may downdrift.
   d. Within the phrase nucleus, a high tone may have a raised allotone, and a low tone may have a lowered allotone or a heavy downglide.
   e. In pre-nuclear position within a word (that is, when in a pre-stressed syllable), a high tone may be lowered, but a low tone may be raised.

Linguistic Factors in Orthography Design

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1. Introduction*

Compared with, say, Europe, orthography development in Africa is in its infancy. Given the growing interest in mother-tongue literacy however, the issue of orthography design is destined soon to be a “hot topic” in the African context. An orthography is not something a single person develops, but rather something a society develops. Nevertheless, it often falls to one or two people to at least design the initial proposal. With all due respect to nonlinguists, an orthography really needs to be designed by someone with adequate linguistics training, who is aware of and sensitive to the local political and social factors that can affect that orthography. The present work is directed towards making linguists aware of some of the linguistic factors that are involved in orthography design.

Linguists, literacy development workers, and the societies they work with should all have the attitude that the orthographies they design will undergo change for years to come. This is a natural and healthy process and should not be discouraged. So expect criticism, and plan to revise the orthography from time to time. The above notwithstanding, one does want to avoid unnecessary criticism. Often, criticism comes from people who are far removed from the scene of the action, who understand little enough about what they are criticizing, but who are nevertheless influential. Two ways to help avoid unnecessary criticism are: a) to have a good orthography to begin with, and b) to prepare a good orthography guide that explains not only how the orthography is designed, but also the reasoning behind many of the decisions taken. I recommend publishing an orthography guide as frontal material in a lexicon or dictionary, and disseminating it as early as possible in a literacy program.

There will always be tension between an orthography that is ideal for writers, and one that is ideal for readers. For example, an easy orthography for writers would be one in which each word is represented by a short dash. Since all words would be “spelled” the same, people could learn to write with only a few minutes of instruction. But such an

*An earlier version of this paper was presented at the Literacy Consultants’ Training Seminar, SIL, Yaoundé, August 19-29, 1998. I wish to thank Connie Kutsch Lojenga and Jim Roberts for many stimulating conversations on orthography that have helped shape my ideas over the years. I also want to acknowledge Steven Bird’s extensive feedback on the final version. Thank you Steven, your comments were most helpful. The usual disclaimers apply.

1 For an enlightening discussion on this subject, see Bird (2001).
orthography would be impossible to read because it wouldn’t encode enough contrast for readers to distinguish the meaning. We therefore need to aim for a compromise that adequately meets the needs of both readers and writers.²

Redundancy is built into language at every level: the pragmatic situation, discourse structure, syntax, morphology and phonology. When the communication situation is less than ideal and part of the speech signal is lost (e.g., a lawn mower roaring outside a window), redundancy allows the intended message to nevertheless be communicated. Just as redundancy allows people to communicate well when the communication channel is less than perfect, so too, it can allow people to communicate well when the orthography is less than ideal. This means that we do not have to have a linguistically “perfect” orthography. The fact that not everything encoded in speech has to be encoded in an orthography gives the orthography designer a certain degree of flexibility. I advocate striving for an “optimal” orthography, as opposed to a “perfect” orthography. An optimal orthography is one built on compromise and may be less than ideal with respect to any given aspect, but which nevertheless accommodates as many factors as possible. The redundancy built into language allows us this flexibility. While language redundancy allows one a certain degree of flexibility when designing an orthography, it should not be used to excuse inadequate prerequisite linguistic analysis. In other words, it should not be taken “for granted.” Just as there are limits to communicating when the communication channel is less than perfect, there are also limits to communicating when the orthography is less than perfect.

One further word of caution. While it is true that one should expect to revise an orthography, realize that the longer an orthography is in use, the more difficult it becomes to change. For this reason, it is important for an orthography to be as good as possible before it is first introduced to a society. In other words, do your initial research well.

2. Orthography and Linguistics

Mature readers read by sight (Venezky 1970), and do not take the time to sound out the words they read. For this reason, a good orthography maintains a constant word-image. This helps minimize the effort it takes for a developing reader to memorize the shape of each word. By the same token, beginning readers often do sound out their words. For this reason, a good orthography bases the spelling of its words as closely as possible on the way the native speaker perceives the words to sound. One of the greatest obstacles to spelling words with a constant word-image the way the native speaker perceives them to sound is that the pronunciation of words changes in different environments.³ It is therefore important to investigate closely the rules that produce the changes in question. In general, spell words the way they sound after word rules have applied, but before phrase rules have applied.

² For further discussion on this point, see Chapter 1 of Finegan (1989).
³ This is true only for alphabetic orthographies. A logographic orthography, in which there is a one-to-one correspondence between a symbol and a word or morpheme, sidesteps this issue, of course.
2.1 How to discover word rules

In order to help discover which rules are word rules, ask the following questions:

1. Does a given rule apply across the board without exception, or are there lexical exceptions? In other words, in the same grammatical and phonological environment do some words undergo a particular rule while others do not? If there are lexical exceptions to a particular rule, then it is important to spell words that undergo that rule the way they sound after the rule has applied.

2. Does a given rule lack phonetic motivation? For most rules, we can see a phonetic reason for why the rule’s output sounds the way it does. For example, sounds often assimilate to certain qualities of other sounds. If however, a particular phonological rule does not have any phonetic motivation whatsoever, then spell the word the way it sounds after the rule has applied.

3. When a given rule applies, is it necessary to refer to the internal structure of the word in the rule’s environment? In other words, does the rule have to apply across a morpheme boundary? Note that we are NOT talking about a word boundary. If the rule must apply across a morpheme boundary, then the word should be spelled the way it sounds after the rule has applied.

As stated above, spell words the way they sound after word rules have applied.

2.2 How to discover phrase rules

In order to help discover which rules are phrase rules, ask the following questions:

1. When a given rule applies, is the new sound it produces one of the contrastive sounds in the language? If the output of the rule is not a phoneme, then spell the word the way it sounds before the rule has applied. For example, if a language has the phonemic vowel inventory i, e, a, o, and u, and a particular rule changes o into a new allophone ɔ, spell the word with an o and not with the ɔ.

2. When a given rule has applied, do native speakers think that the sound that results is the same as or different from the sound that underwent the rule. If they think it is the same sound, that is, they don’t realize that anything has changed without having the change pointed out to them, then spell the word the way it sounds before the rule has applied. Consider this English example. When a native speaker pluralizes the word cap, he says [kaps]. However, when he pluralizes the word cab, he does not say [kabs], but rather [kabz]. Unless he has had linguistic training or has been informed in some other way, the native English speaker is not immediately aware that he says the plural differently in the two cases, even though /s/ and /z/ do contrast in other environments in the language. The English orthography is therefore correct in not spelling these words the way they sound to a linguist. These words are, however, spelled the way native speakers perceive them to sound.

3. When a given rule applies, is it necessary to refer to the internal structure of the phrase in the rule’s environment? In other words, does the rule have to apply across a word boundary? Note that we are NOT talking about a morpheme boundary. If the

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4 This section and the next owe a great deal to the theory of lexical phonology. For a detailed overview of lexical phonology, the interested reader is referred to Kenstowicz (1994). For a clear presentation of the differences between word rules (viz. lexical rules) and phrase rules (viz. postlexical rules), see Pulleyblank (1986).
rule must apply across a word boundary, then the word should be spelled the way it sounds before the rule has applied. This means that the word-image does not change even though the word may be pronounced differently in the context of other words.

As stated above, spell words the way they sound after word rules have applied. In other words, disregard phrase rules in your orthography.

Following the above criteria helps to establish where word breaks should occur\(^5\) and eliminates the representation of low-level allophonic variation. It also eliminates the effect of rules that apply across word boundaries and the effect of phrase initial and phrase final phenomena. This allows one to: a) maintain a constant word-image and thereby meet the needs of mature readers, and b) write words the way the native speaker perceives them to sound and thereby meet the needs of beginning readers. One implication of this strategy for writing tone is that many changes that occur as a result of “grammatical tone” are reflected in the orthography.

A word of caution. Although the above principles present a way to rigorously determine what should be written and what should not be written, it offers only a promising beginning point for people to try. As with everything else in orthography design, try something and then test it thoroughly. We return to the matter of orthography testing below.

### 2.3 Tone and orthography

Tonal phenomena present some of the greatest challenges to good orthography design in Africa. This is largely due to the phenomenon of floating tones, i.e., tones whose presence can only be detected when the morphemes they are part of are put into larger contexts such as words or phrases. In Dzuungo (Burkina Faso) there is often a floating high tone at the right edge of words. In the following examples (data courtesy of Paul Solomiac), the nouns in their singular forms all sound the same tonally (i.e., they all have low tone, indicated by grave accents). There is a floating high tone at the right edge of the last two examples, however, that manifests itself as a high tone on the following plural suffix (indicated by an acute accent). One can think of floating tones as similar to the \(n\) in *hymn* (pronounced [hIm]). When we add the suffix \(-al\) to it, the \(n\) is pronounced (viz. [hImnal]).

<table>
<thead>
<tr>
<th>Singular</th>
<th>Plural</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>cì</td>
<td>cì-rèè</td>
<td>‘corn fufu’</td>
</tr>
<tr>
<td>jìjà</td>
<td>jìjà-nèè</td>
<td>‘kitchen sling’</td>
</tr>
<tr>
<td>fà</td>
<td>fà-nèè</td>
<td>‘side’</td>
</tr>
<tr>
<td>gbìrì</td>
<td>gbìrì-lèè</td>
<td>‘crocodile’</td>
</tr>
</tbody>
</table>

If the floating tone manifests itself as the result of a word rule, as in these Dzuungo examples, the effect should be written orthographically because word rules should have orthographic representation. However, floating tones that manifest themselves across a word boundary (e.g., on adjacent words) can pose particularly difficult problems for

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\(^5\) Only those criteria which do not make crucial reference to word boundaries are useful in determining where word breaks occur. Otherwise, this is a circular argument.
orthographies. In these next Chumburung (Ghana) examples, the word for ‘smoke’ ends in a floating low tone and contrasts with the word for ‘woman,’ which does not end in a floating low tone.

\[\text{Ibər} \quad \text{‘smoke’} \quad \text{Ibər ‘sə} \quad \text{‘smoke’s scent’} \]

\[\text{ṣṣf} \quad \text{‘woman’} \quad \text{ṣṣf sə} \quad \text{‘woman’s scent’} \]

In Chumburung, the floating low tone has no effect on the word to which it is assigned; but when you put another high-toned word after it, that second high-toned word is downstepped (indicated by the small down arrow). Since this happens across word boundaries, the process is clearly phrasal. If one represents downstep on the word that undergoes it, one will not be able to maintain a constant word-image. Nevertheless it is important to distinguish words like ‘smoke’ from words like ‘woman.’

This is not an uncommon problem, and my suggested solution is to represent words that have floating tones in a manner different from words that do not have floating tones. In other words, make the difference appear on the word that causes the difference, as opposed to on the adjacent word that undergoes the change. Since we need to represent each tone melody in a unique fashion anyway, and since the floating tone of a particular word is part of its inherent melody, it only stands to reason that the word that has the floating tone should be the one that gets the special treatment.

One question that I am sometimes asked concerning tone and orthography is whether one needs to mark all tones. For instance, if one has a “three-tone” system with high, mid, and low level tones, should one leave the mid unmarked and mark only high and low? Or can one get away with marking high only, or perhaps low only? And what about rising and falling tones? I have heard vigorous debates over whether in a “two tone” system one should mark high tone only or low tone only. Unfortunately, these are not the questions to ask. Asking them is tantamount to asking an automobile mechanic whether red cars are better than green cars. The real issues at stake with respect to tone and orthography are what tonal melodies are in contrast and at what level of the phonology (underlying, surface, phonemic, etc.) is the native speaker most aware of these contrasts. So discussing how to represent contrasts is really secondary to discussing which contrasts to represent and at what level of the phonology they should be represented at.

Bird (1999a) presents a number of different strategies for representing tone in orthography, and I discuss some of these here.

Surface tone marking
Surface tone marking is simply marking tone the way it is pronounced phonetically. This strategy is difficult for both reading and writing for at least two reasons, and it should be avoided. First, surface tone marking forces a writer to sound out everything in his mind before he writes it down. This is particularly difficult to do when it is necessary to represent the output of rules that apply across word boundaries. Although writing surface tone can be helpful for beginning readers in certain parts of texts, in other parts it is not helpful at all because beginning readers can’t read fast enough to make sense of tone rules that apply across word boundaries. As for mature readers, an orthography that marks surface tone slows them down since they are forced to sound everything out before
they can understand the meaning. As mentioned above, mature readers read by sight, and so it is advantageous for an orthography to maintain fixed word-images.

The second reason why surface tone marking should be avoided is because not all surface sounds are meaningful to native speakers (e.g., low-level allophonic sounds). After all, why do we bother to analyze languages linguistically? If all that is needed is to write languages the way they sound, it would only be necessary for those who develop orthographies to study phonetics. We don’t advocate writing phonetic forms for nontonal phenomena, so we shouldn’t advocate writing them for tonal phenomena.

**Zero tone marking**

Not marking tone in any way is probably the easiest strategy for writing, but it can pose problems for reading comprehension. Whether it does pose problems for readers or not depends on how great a functional load tone bears. One way to determine how great the functional load is is to take texts of varying degrees of difficulty, not mark tone on them in any way, and then use them to test reading fluency and comprehension (see below).

Beware of comparing the test results of a zero marked text with those of a text marked using an existing orthography. This is most often done when the researcher notices that writers have difficulties marking tone in the existing orthography and wonders whether tone even needs to be marked at all. When a comparison like this is made, the difference in results between the two tests is often not statistically significant, and so the researcher concludes that tone doesn’t need to be marked. I suspect that the reason why the results of the two tests are so comparable is that the subjects in the tests aren’t looking at the tone marks in either study because the tone marking in the existing orthography is poor to begin with.

A better strategy when testing a zero marked text is to note in particular where the difficulties lie, if indeed there are difficulties. If there do not seem to be great difficulties, this is not a bad strategy to follow. But if there are difficulties, then it will probably be best to implement one of the other strategies discussed below.

**Marking only minimal pairs**

In some languages, the functional load of lexical tone is light, but there are nevertheless several words whose tonal melodies are the sole indicators that they are different from other words. If there are not too many words like this, it is sometimes advisable not to mark lexical tone, but rather to mark one or both members of a minimal pair with diacritic marks. But if there are several minimal pairs, this strategy doesn’t work well. There are at least three problems:

1. Writers can’t remember which words have a “partner” and which don’t. So they never know which words to mark and which not to mark.
2. Readers sometimes have difficulty remembering which member of the minimal pair a particular mark represents.
3. Inevitably, more minimal pairs show up later which never get taught.

To the extent that this strategy is employed, it needs to be taught well. However many words are set apart with diacritic marking, they need to be completely memorized by the students.

**Diacritic marking of grammatical tone**
Diacritic marking of grammatical tone can be successfully employed when tone does not play a great role in distinguishing lexical items, but there is nevertheless a significant number of grammatical distinctions indicated by tonal differences. In this case, one does not mark “tone” per se. Instead, one uses diacritics in a consistent manner to indicate the different grammatical distinctions. An acute accent on the verb, for instance, might be used to signal perfective aspect, regardless of how tone is realized in this construction. Similarly, a circumflex might indicate imperfective aspect, etc.

Output of word rules
If none of the above strategies is feasible, write words as they are defined after word rules have applied (see above). As discussed above, this strategy allows one to maintain a constant word-image and thereby meet the needs of mature readers, and it allows one to write words the way the native speaker perceives them to sound and thereby also meet the needs of beginning readers.

2.4 Teaching tone in orthography
Following Kutsch Lojenga (1986, 1993), I suggest teaching tone as early as possible in the primer. Don’t wait until all the consonant s and vowels have been taught. Teach tone in terms of contrastive word melodies, not in terms of high vs. low vs. mid. Think of the melody as the phoneme of tone. Always contrast one complete word melody with another complete word melody. Devote the same amount of time to any given melody as you would to any given segmental phoneme. Pay particular attention to any melodies that have floating tones. In general, this will mean having a lot more lessons devoted to tone than is normally the case in most African literacy programs.

3. Orthography Testing
As mentioned above, the advice suggested in this paper offers promising beginning points for orthographies. As with everything in orthography design however, all proposals must be tested thoroughly. When testing an orthography, it is important to always test two groups: a test group and a control group. It is also important that both groups be adequately and comparably trained. One two-hour teaching session immediately prior to administering the test to one group can hardly be compared with the perhaps weeks of training that went into, say, the control group before they took their test. Finally, it is important for the test to involve material that has differing degrees of difficulty.

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6 For additional discussions about and examples of this strategy, the interested reader is referred to Edmonson (1969), Meier (1983), Ernst (1996a, b), and Snider (1992).
7 Literature on experimentation in orthography includes Henderson (1984), and Frost and Katz (1992), and Frost (1994). For descriptions of testing tone in orthography as it pertains to African languages, see Eissen (1977), Mfonyam (1989), and Bernard, Mbeh, and Handwerker (1995, 1997). For an additional description, see Bird (1999b), which also provides a critique of these works.
3.1 What to test?
My observation is that most orthography testing that has been carried out in Africa has focused on the testing of comprehension and oral reading fluency. Equally important, however, is the testing of writing.

When testing reading, there are two aspects that need to be tested, comprehension and fluency. Comprehension can be tested by having subjects read one or more selections and then asking content questions. Fluency can be tested by having subjects read one or more selections orally and then noting the places where they stumble. The people who conduct the test should record the different readings on audio cassette, and then later note the number and type of reading errors made.

When testing writing, there are also two aspects that need to be tested, accuracy and speed. Accuracy can be tested by giving a dictation exercise, and noting the number and type of errors made. Speed is more difficult to test. This can be done by timing individual dictation exercises.

3.2 How many people does one need to test?
Many people ask this question, and there is no easy answer to it. In order to know which of two orthographies is better (e.g., the new orthography vs. the old orthography), there need to be enough subjects in each group so that any difference in results between the two groups is statistically significant. How large is large enough depends on how homogenous the results are. The more homogenous the results, the smaller the sample size needs to be; the less homogenous the results, the greater the sample size needs to be. If student scores for one of the groups are all reasonably close to the average score, then the results are fairly homogenous (smaller sample size needed). On the other hand, if the individual scores differ wildly from each other, then the results are less homogenous (larger sample size needed). One can test whether the difference between results for different test groups is statistically significant by submitting the scores to a Student’s T-TEST using a computer spreadsheet such as Microsoft Excel. If the scores turn out not to be statistically significant then one needs to increase the sample size (i.e., test more students).8

4. Summary
I close by summarizing in point form the main ideas of this paper:
1. Plan to revise the orthography from time to time.
2. Strive for an optimal orthography based on compromise, not a perfect orthography.
3. In general, spell words the way they sound after word rules have applied, but before phrase rules have applied.

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8 Statistical significance for tests like this can be determined by conducting an unpaired, two-tailed, unequal variance Student’s T-TEST. This test gives you a probability, or p-value. The values range from 0.0 (100% probability that the difference between the two means is statistically significant) to 1.0 (100% probability that the difference between the two means is not statistically significant). Following standard statistics practice, we assume a p-value of 0.05 or lower before we consider the difference between two means to be statistically significant.
4. Represent words that have floating tones in a manner different from words that do not have floating tones. In other words, make the difference appear on the word that causes the difference, as opposed to on the adjacent word that undergoes the change.

5. When lexical tone carries a low functional load but a high grammatical load, consider not marking tone, but rather using diacritics in a consistent manner to indicate the different grammatical distinctions.

6. Teach tone as early as possible in literacy classes.

7. Teach tone in terms of contrastive word melodies, not in terms of high vs. low vs. mid.

8. Test the orthography rigorously, and when doing so be sure to test comprehension, oral reading fluency and writing.

9. Finally, when testing the orthography, ensure that the sample size is large enough so that any difference in results is statistically significant.

There are many factors involved in orthography design, and the linguistic factors we have focused on in this paper are only one area of consideration. It is important for the linguist to realize that an orthography is not developed in a vacuum and that the other factors are equally important to consider. A good orthography is therefore built on compromise. Due to the redundancy built into language, linguists are in a good position to make that compromise.

References


Parameters for grid construction


1. stressable elements: {syllables, moras}

2. foot constituency: {bounded, unbounded}
   Note that bounded feet are usually binary.

3. direction of parsing: {left to right, right to left}

4. headedness: {left-headed, right-headed, head medial}
   - left-headed = trochaic
   - right-headed = iambic
   - head-medial = amphibrach
   - non-branching feet = degenerate

5. relevance of weight: {quantity-sensitive, quantity-insensitive}

6. extrametricality: {on, off}
   Limited to one stress-bearing element at the periphery of a morphological domain.

7. clash removal: {on, off}

8. line conflation: {on, off}

Exhaustivity Condition: every stress-bearing unit must be included in some constituent (except those which are licensed by extrametricality).
Stress patterns in Chamicuro

1. čáyi ‘ear’
2. áhsi ‘tooth’
3. timíli ‘wind (noun)’
4. ahkóči ‘house’
5. akíʔšo ‘cane; walking stick’
6. ákumáwa ‘boa constrictor’
7. àhkelóhki ‘heart’
8. ámehkisi ‘needle’
9. čáyčaʔtéči ‘earring’
10. akáčelóʔta ‘true; right’
11. anáskaňnéye ‘something’
12. ašpihkaʔcáči ‘whip (noun)’
13. čepólalíhsa ‘manioc beer’
14. čiʔnáštaláči ‘town, village’
15. kaʔčákamáwa ‘yellow’
16. maččéʔpelíhši ‘coriander spice’
17. maʔpòhtaʔmálo ‘four’
18. irekálastále ‘he is giving it’
19. išákatískále ‘abandoned’
20. kápapèskahpóla ‘ambitious’
21. mèyanáʔšanáye ‘nobody; nothing’
22. úpačútakéli ‘my godfather’
23. úpaʔsáknanísti ‘nausea’
24. wahtopòhkašhti ‘I am smoking (a cigarette)’
25. yákatihkačópi ‘footprint’
26. yášnaʔkàyatúní ‘bored’
27. išákatúʔkulúʔto ‘they are playing with it’
28. ušákatóʔkulúʔti ‘I am playing’
29. úšanåtåʔčómawáni ‘I am working’

*Kana acha’taka ijnachale kana chamekolo (Chamicuro texts and vocabulary)*. Comunidades y Culturas Peruanas no. 21. Yarinacocha, Pucallpa, Peru: Instituto Lingüístico de Verano.
Palauan stress


<table>
<thead>
<tr>
<th>Present</th>
<th>Future Participle (innovative)</th>
<th>Future Participle (conservative)</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. mədəŋəb</td>
<td>dəŋəbáll</td>
<td>dəŋóbl</td>
<td>‘cover’</td>
</tr>
<tr>
<td>2. mətèteʔəb</td>
<td>təʔəbáll</td>
<td>təʔíbl</td>
<td>‘pull out’</td>
</tr>
<tr>
<td>3. məŋetəm</td>
<td>ɳətəmáll</td>
<td>ɳətóml</td>
<td>‘lick’</td>
</tr>
<tr>
<td>4. mətábək</td>
<td>təbəkáll</td>
<td>təbákl</td>
<td>‘patch’</td>
</tr>
<tr>
<td>5. məʔarəm</td>
<td>ʔərəmáll</td>
<td>ʔəróml</td>
<td>‘taste’</td>
</tr>
<tr>
<td>6. məsesəb</td>
<td>səsəbáll</td>
<td>səsóbl</td>
<td>‘burn’</td>
</tr>
</tbody>
</table>
### Metrical foot typology

<table>
<thead>
<tr>
<th>foot type</th>
<th>quantity-sensitivity</th>
<th>example (language)</th>
<th>minimum no. of μ</th>
<th>maximum no. of μ</th>
<th>ideal no. of μ</th>
<th>best (optimal) manifestations</th>
<th>other possible manifestations</th>
<th>impossible manifestations</th>
</tr>
</thead>
<tbody>
<tr>
<td>syllabic trochee</td>
<td>quantity insensitive</td>
<td>Chamicuro</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>(ĤL)</td>
<td>(ĤH), (ĤL) &gt; (Ĥ) &gt; (Ĥ) &gt; (Ĥ)</td>
<td>*(σσ̂)</td>
</tr>
<tr>
<td>moraic trochee</td>
<td>quantity sensitive</td>
<td>Palauan</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>(Ĥ), (ĤL)</td>
<td>(Ĥ)</td>
<td>*(ĤL) &gt; *(ĤH) &gt; *(ĤL) &gt; *(σσ̂)</td>
</tr>
<tr>
<td>iamb</td>
<td>quantity sensitive</td>
<td>Asheninca</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>(ĤL)</td>
<td>(Ĥ), (ĤL) &gt; (Ĥ) &gt; (Ĥ) &gt; (Ĥ)</td>
<td>*(ĤH) &gt; *(ĤL) &gt; *(σσ̂)</td>
</tr>
</tbody>
</table>

In the chart above, “>” means ‘inherently better than (more harmonic)’.

Some generalizations:

The minimum number of moras in any foot, regardless of type, is one. This is a degenerate foot made up of a single light syllable: (Ĥ). This will always be the least preferred parse among the possible options (manifestations), regardless of language.

The maximum number of moras diverges among the three types of feet. The maximum number of moras per foot is not necessarily the best option. Specifically, even though syllabic trochees may contain four moras — (ĤH) — the ideal syllabic trochee has just three moras: (ĤL).
All else being equal, a foot consisting of two syllables is better than a foot consisting of just one syllable.

All else being equal, a foot consisting of at least two moras is better than a foot consisting of just one mora.

All else being equal, a heavy (bimoraic) syllable makes a better foot head (stress bearing unit) than a light syllable does. In other words, $\H > \L$, regardless of foot type. This constraint is called Peak Prominence or the Stress-to-Weight Principle (SWP). Another way in which it is sometimes expressed is, “If stressed, then heavy.”

A corollary to this is that, all else being equal, a light (monomoraic) syllable makes a better foot nonhead (unstressed member) than a heavy syllable does: $\L > \H$. In other words, “If unstressed, then light.”

All else being equal, a heavy syllable should be stressed. In other words, $\H > \H$. This is called the Weight-to-Stress Principle (WSP): “If heavy, then stressed.” This constraint is the primary force driving the determination of what makes a language quantity-sensitive.

All else being equal, a light syllable should not be stressed: $\L > \L$. In other word, “If light, then unstressed.”

Some illustrative parses exemplifying the three basic foot types, given a hypothetical word containing 25 syllables, and leaving aside potential complications such as morphology (roots vs. affixes), stress clash, degenerate feet, extrametricality, etc.

$L H L H L H L L H H L H L L L L H H L L$ [likely gloss: ‘flabbergasted’]

- syllabic trochee, left-to-right: $(\L)(\L)(\L)(\L)(\L)(\L)(\L)(\L)(\L)(\L)(\L)$
- syllabic trochee, right-to-left: $L(\L)(\L)(\L)(\L)(\L)(\L)(\L)(\L)(\L)(\L)(\L)$
- moraic trochee, left-to-right: $L(\L)L(\L)(\L)(\L)(\L)(\L)(\L)(\L)(\L)(\L)(\L)$
- moraic trochee, right-to-left: $L(\L)L(\L)(\L)(\L)(\L)(\L)(\L)(\L)(\L)(\L)(\L)$
- iamb, left-to-right: $(L\L)(L\L)(L\L)(L\L)(L\L)(L\L)(L\L)(L\L)(L\L)$
- iamb, right-to-left: $(L\L)(L\L)(L\L)(L\L)(L\L)(L\L)(L\L)(L\L)(L\L)$
Some comments and observations:

When the word being parsed has an EVEN number of syllables and the foot type is a syllabic trochee, the directionality parameter does not matter; the same result will be derived either way because syllabic trochees are quantity-insensitive and thus always encompass two syllables, regardless of weight (number of moras).

When the word being parsed has an ODD number of syllables (as above) and the foot type is a syllabic trochee, directionality does matter. In this case there will be a left-over single syllable at the opposite end of the word from where footing begins.

Even in those cases when the word being parsed has an EVEN number of syllables, directionality can matter for the two foot types which are quantity-sensitive. For moraic trochee languages, the difference in direction of parsing shows up whenever we encounter a sequence of three light syllables in a row, regardless of the total number of syllables in the word. For example, in the hypothetical word above, notice where the only difference emerges for the contrasting moraic trochee parses, copied below:

- left-to-right: \( \text{LL} (\text{H}) (\text{H}) (\text{H}) (\text{L}) (\text{L}) (\text{H}) (\text{H}) (\text{H}) (\text{L}) (\text{H}) (\text{L}) (\text{H}) \)
- right-to-left: \( \text{LL} (\text{H}) (\text{H}) (\text{H}) (\text{H}) (\text{L}) (\text{L}) (\text{H}) (\text{H}) (\text{H}) (\text{L}) (\text{H}) (\text{L}) (\text{H}) \)

In iambic languages, the result of parsing in different directions can be even more dramatic. Since iambics can contain up to three moras, they are inherently bigger and more flexible than moraic trochees, which consist of at most two moras (one heavy syllable or two lights). Given this, iambic parses are sensitive to the direction of parsing whenever just two light syllables are juxtaposed. In the contrasting parses below (repeated from above), notice that if exhaustivity is relaxed such that degenerate feet are avoided, longer words can actually have different numbers of iambic feet:

- left-to-right: \( (\text{L}) (\text{H}) (\text{L}) (\text{H}) (\text{H}) (\text{L}) (\text{H}) (\text{H}) (\text{L}) (\text{L}) (\text{L}) (\text{L}) ) \) [15 feet]
- right-to-left: \( (\text{L}) (\text{H}) (\text{L}) (\text{H}) (\text{H}) (\text{L}) (\text{L}) (\text{H}) (\text{H}) (\text{H}) (\text{L}) (\text{L}) (\text{L}) (\text{L}) (\text{L}) ) \) [13 feet]
### Latin stress

<table>
<thead>
<tr>
<th>Monosyllabic words</th>
<th>Disyllabic words</th>
<th>Trisyllabic words</th>
</tr>
</thead>
<tbody>
<tr>
<td>árks</td>
<td>fálanks</td>
<td>ádeps</td>
</tr>
<tr>
<td>dúks</td>
<td>árkis</td>
<td>ápeks</td>
</tr>
<tr>
<td>dáps</td>
<td>dúkis</td>
<td>ékwes</td>
</tr>
<tr>
<td>sél:ps</td>
<td>dápis</td>
<td>filiks</td>
</tr>
<tr>
<td>ré:ks</td>
<td>sél:pis</td>
<td>lápis</td>
</tr>
<tr>
<td>úrps</td>
<td>ré:gis</td>
<td>árbor</td>
</tr>
<tr>
<td>pléps</td>
<td>úrbis</td>
<td>púgil</td>
</tr>
<tr>
<td>lí:s</td>
<td>plélbis</td>
<td>nó:men</td>
</tr>
<tr>
<td>fráw:is</td>
<td>lí:tis</td>
<td>kármen</td>
</tr>
<tr>
<td>fróns</td>
<td>frón:dis</td>
<td>lú:men</td>
</tr>
<tr>
<td>dén:is</td>
<td>frón:ris</td>
<td>wé:ris</td>
</tr>
<tr>
<td>só:ris</td>
<td>dén:ris</td>
<td>múr:mur</td>
</tr>
<tr>
<td>wé:r</td>
<td>dén:ris</td>
<td>múr:mur</td>
</tr>
<tr>
<td>sál:1</td>
<td>sór:ris</td>
<td>áktyo:</td>
</tr>
<tr>
<td>fú:r</td>
<td>bú:bo:</td>
<td>gé:rr:o:</td>
</tr>
<tr>
<td>fár</td>
<td>népo:s</td>
<td>inkú:dis</td>
</tr>
<tr>
<td>ás</td>
<td>fú:ris</td>
<td>fár:ris</td>
</tr>
<tr>
<td>ós</td>
<td>ássis</td>
<td>óssis</td>
</tr>
<tr>
<td>ó:s</td>
<td>ó:ris</td>
<td>fló:ris</td>
</tr>
<tr>
<td>fló:s</td>
<td>mú:ris</td>
<td>amánda</td>
</tr>
</tbody>
</table>

Classical Arabic stress

1. lán  ‘not’
2. fáqat  ‘only’
3. málikun  ‘a king’
4. malikatun  ‘a queen’
5. malikátuhu  ‘his queen’
6. maktabatun  ‘a library’
7. maktabátuhu  ‘his library’
8. yastaq bíluhu  ‘he receives him (as a guest)’
9. jā:wárahu  ‘it bordered it’
10. yu:já:wíruhu  ‘it borders it’
11. kássarat  ‘she smashed’
12. kasártu  ‘I broke’
13. kassártuhu  ‘I smashed it’
14. kasártuhu  ‘I broke it’
15. sa:fártu  ‘I traveled’
16. qábla  ‘before’
17. kitá:bun  ‘a book’
18. ká:tibun  ‘a writer’
19. kassarú:hu  ‘they smashed it’
20. kasarí:hu  ‘we broke it’
21. sá:fara  ‘he traveled’
22. ka:tibi:na  ‘writers’

Sources of these data:


Motivation for metrical phonology

Arguments for (advantages of) the grid parameters of metrical phonology (MP) compared with the formalisms of SPE theory for writing stress rules (cf. Latin and Arabic):

(1) MP directly invokes/encodes the notion of the syllable; SPE does not (to its detriment).

(2) Stress typically affects consonants as much as it does vowels; SPE does not predict this since its formal stress rules apply only to vowels.

(3) The existence of secondary stress is natural, simple, unmarked, preferred, and default. SPE gets this backwards because it costs more to have secondary stress (we have to write a second rule). In MP this is captured by simply leaving Line Conflation turned off (the default option). When secondary stress does not show up, MP captures this by turning Line Conflation on, which implies a more marked (complicated) language.

(4) MP captures the fact that stress is unlike other phonological features because we have a different type of formal mechanism or device for encoding it (grids). SPE uses the same rule notation for stress assignment as for all other phonological processes. But stress is unique because it doesn’t assimilate, is limited to one occurrence per word (for primary stress), normally has to exist in every word (major class lexical items), has to obligatorily alternate (for secondary stress), etc.

(5) MP’s parameters are less powerful and more restrictive than SPE rules. For example, with grid parameters, primary stress will always fall within a three syllable window at the beginning or end of the word (unless the word is morphologically complex). But except for this latter complication, in MP we can’t put stress on the middle (fifth) syllable of a nine-syllable word, whereas in principle we could write an SPE rule to put stress anywhere at all.

(6) SPE falsely implies that word-final stress is less complicated and more simple than penultimate stress, in terms of its evaluation metric. This is because it is easier to state the environment “word-finally” than “penultimate” (fewer things to stipulate in the structural description of the rule). But in the languages of the world, penultimate stress is much more common and default than ultimate stress. So SPE theory gets this backwards. MP, on the other hand, predicts that both locations of stress should be equally unmarked since it costs the same to produce either one. In this respect MP is not perfect, but at least it is moving in the right direction. In other words, we haven’t completely solved this problem yet, but we are improving in terms of accurately accounting for the empirical facts of the world’s languages.

(7) SPE rules completely overlook and ignore metrical feet. This is bad. MP, on the other hand, directly incorporates the notion of feet in its formalisms, by explicitly making them part of several different basic parameters. In addition, we can overtly see the feet in the grids.
Sherlock Holmes, phonologist

1. deductive (backwards) reasoning

2. don’t jump to conclusions before you have all the relevant data

3. detail-oriented

4. a simple situation may have a complex explanation, and a complex set of facts may have a simple explanation

5. well-read in the literature of his field (“There’s nothing new under the sun.”)

6. passionate about his job

Arthur Conan Doyle: “A study in scarlet”
Introduction to Optimality Theory and tableaux

Some basic constraints:

(Faithfulness type: monitor the input/output mapping)

**Parse**  “Do not delete anything.”

**Dep**  “Do not insert anything.”

(The output depends on the input.)

N.B.: This replaces the earlier “Fill” constraint.

(Markedness type)

**Onset**  “Every syllable must begin with a consonant.”

Or, vowel-initial syllables are prohibited:  * _σ[V

**NoCoda**  “No syllable may end with a consonant.”

Or, consonant-final syllables are prohibited:  * C] _σ

Note that given just these four constraints, no language will every lack CV syllables entirely. Furthermore, no language will ever syllabify the string /VCV/ as *[VC.V] unless some other markedness constraint is involved.

A typical Jakobsonian CV language (with epenthesis)

Some characteristic derivations:

/pati/  →  [pa.ti]  (completely faithful parse)

/pai/  →  [pa.wi]  (onset epenthesis)

/pakti/  →  [pa.kə.ti]  (nucleus epenthesis)

(1)  **ONSET**  »  **DEP**  (ONSET dominates or outranks DEP.)

<table>
<thead>
<tr>
<th>Input: /pai/</th>
<th>ONSET</th>
<th>DEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pa.wi]</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. [pa.i]</td>
<td></td>
<td>!</td>
</tr>
</tbody>
</table>

(2)  **NoCoda**  »  **DEP**  (It is better to insert something than to have a coda.)

<table>
<thead>
<tr>
<th>Input: /pakti/</th>
<th>NoCoda</th>
<th>DEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pa.kə.ti]</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. [pak.ti]</td>
<td></td>
<td>!</td>
</tr>
</tbody>
</table>
(3) \textsc{Parse} \Rightarrow \textsc{Dep} \quad \text{(It is better to insert something than to delete something.)}

<table>
<thead>
<tr>
<th>Input: /pai/</th>
<th>\textsc{Parse}</th>
<th>\textsc{Dep}</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pa.wi]</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. [pi]</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>c. [pa]</td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

(4) \textsc{Parse} \Rightarrow \textsc{Dep}

<table>
<thead>
<tr>
<th>Input: /pakti/</th>
<th>\textsc{Parse}</th>
<th>\textsc{Dep}</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pa.kə.ti]</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. [pa.ki]</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>c. [pa.ti]</td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

(5) Overall ranking: \textsc{Onset, NoCoda, Parse} \Rightarrow \textsc{Dep}

(6) Summary tableaux:

<table>
<thead>
<tr>
<th>Input: /pati/</th>
<th>\textsc{Onset}</th>
<th>\textsc{NoCoda}</th>
<th>\textsc{Parse}</th>
<th>\textsc{Dep}</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pa.ti]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [paw.ti]</td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c. [pa]</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input: /pai/</th>
<th>\textsc{Onset}</th>
<th>\textsc{NoCoda}</th>
<th>\textsc{Parse}</th>
<th>\textsc{Dep}</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pa.wi]</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. [pa.i]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. [paw.ti]</td>
<td>*!</td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>d. [pa]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. [pi]</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input: /pakti/</th>
<th>\textsc{Onset}</th>
<th>\textsc{NoCoda}</th>
<th>\textsc{Parse}</th>
<th>\textsc{Dep}</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pa.kə.ti]</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. [pak.ti]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. [pa.ki]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. [pa.ti]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**************

Another typical Jakobsonian \textit{CV} language (with deletion)

Some characteristic derivations:
/pati/ → [pa.ti] (completely faithful parse)
/pai/ → [pa] (truncation)
/pakti/ → [pa.ti] (coda deletion or “stray erasure”)

(Assignment: in the following tableaux, fill in * for constraint violations, ! for fatal violations, and ì for the winning (optimal or most harmonic) candidates.)

(7) ONSET » PARSE  (It is better to delete a vowel than it is to begin a syllable with a vowel.)

<table>
<thead>
<tr>
<th>Input: /pai/</th>
<th>ONSET</th>
<th>PARSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pa]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [pa.i]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(8) NOCODA » PARSE  (It is better to delete a consonant than it is to have a coda.)

<table>
<thead>
<tr>
<th>Input: /pakti/</th>
<th>NOCODA</th>
<th>PARSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pa.ti]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [pak.ti]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(9) DEP » PARSE  (It is better to delete something than it is to insert something.)

<table>
<thead>
<tr>
<th>Input: /pai/</th>
<th>DEP</th>
<th>PARSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pa]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [pa.wi]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(10) DEP » PARSE

<table>
<thead>
<tr>
<th>Input: /pakti/</th>
<th>DEP</th>
<th>PARSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pa.ti]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [pa.kə.ti]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(11) Overall ranking: ONSET, NOCODA, DEP » PARSE

(12) Summary tableaux:

<table>
<thead>
<tr>
<th>Input: /pati/</th>
<th>ONSET</th>
<th>NOCODA</th>
<th>DEP</th>
<th>PARSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pa.ti]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [paw.ti]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. [pa]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Input: /pai/**

| a. | [pa] |
| b. | [pa.i] |
| c. | [pa.wi] |

**Input: /pakti/**

| a. | [pa.ti] |
| b. | [pak.ti] |
| c. | [pa.kə.ti] |

***************

A different CV(C) language (with epenthesis)

Some characteristic derivations:

- /pati/ → [pa.ti] (completely faithful parse)
- /pai/ → [pa.wi] (onset epenthesis)
- /pakti/ → [pak.ti] (completely faithful parse)

(Assignment: in the following tableaux and ranking statements, fill in the names of the constraints.)

(13) __________ » __________

| Input: /pai/ |  
| a.  | [pa.wi] |
| b.  | [pa.i] | *

(14) __________ » __________

| Input: /pai/ |  
| a.  | [pa.wi] |
| b.  | [pa] | *!
| c.  | [pi] | *!

(15) __________ » __________

| Input: /pakti/ |  
| a.  | [pak.ti] |
| b.  | [pa.kə.ti] | *!
(16) _______ » _______

<table>
<thead>
<tr>
<th>Input: /pakti/</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pak.ti]</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. [pa.ki]</td>
<td></td>
<td>!</td>
</tr>
<tr>
<td>c. [pa.ti]</td>
<td></td>
<td>!</td>
</tr>
</tbody>
</table>

(17) Overall ranking: _______ , _______ » _______ » _______

(18) Summary tableaux:

<table>
<thead>
<tr>
<th>Input: /pai/</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pa.wi]</td>
<td></td>
<td>!</td>
</tr>
<tr>
<td>b. [pa.i]</td>
<td></td>
<td>!</td>
</tr>
<tr>
<td>c. [pi]</td>
<td></td>
<td>!</td>
</tr>
<tr>
<td>d. [pa]</td>
<td></td>
<td>!</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input: /pakti/</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pak.ti]</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. [pa.ti]</td>
<td></td>
<td>!</td>
</tr>
<tr>
<td>c. [pa.kə.ti]</td>
<td></td>
<td>!</td>
</tr>
</tbody>
</table>

*************************
A different CV(C) language (with deletion)

Some characteristic derivations:

/pati/ → [pa.ti] (completely faithful parse)
/pai/ → [pa] (truncation)
/pakti/ → [pak.ti] (completely faithful parse)

(Assignment: in the following tableaux, fill in the appropriate candidates.)

(19) ONSET » PARSE

<table>
<thead>
<tr>
<th>Input: /pai/</th>
<th>ONSET</th>
<th>PARSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pak.ti]</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td>!</td>
</tr>
</tbody>
</table>
(20) **DEP \( \rightarrow \) PARSE**

<table>
<thead>
<tr>
<th>Input: /pai/</th>
<th>DEP</th>
<th>PARSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ( \varepsilon )</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. !</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(21) **DEP \( \rightarrow \) NoCoda**

<table>
<thead>
<tr>
<th>Input: /pakti/</th>
<th>DEP</th>
<th>NoCoda</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ( \varepsilon )</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. !</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(22) **PARSE \( \rightarrow \) NoCoda**

<table>
<thead>
<tr>
<th>Input: /pakti/</th>
<th>PARSE</th>
<th>NoCoda</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ( \varepsilon )</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. !</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. !</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(23) **Overall ranking:** Onset, DEP \( \rightarrow \) PARSE \( \rightarrow \) NoCoda

(24) **Summary tableaux:**

<table>
<thead>
<tr>
<th>Input: /pai/</th>
<th>Onset</th>
<th>DEP</th>
<th>PARSE</th>
<th>NoCoda</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ( \varepsilon )</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. !</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>!</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input: /pakti/</th>
<th>Onset</th>
<th>DEP</th>
<th>PARSE</th>
<th>NoCoda</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ( \varepsilon )</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. !</td>
<td></td>
<td></td>
<td>!</td>
<td></td>
</tr>
<tr>
<td>c. !</td>
<td></td>
<td></td>
<td>!</td>
<td></td>
</tr>
</tbody>
</table>

“No matter how sophisticated, liberal, or open minded a field worker thinks he or she is, the tyranny of what you know, innately or through learning, is awesome — it prevents you from seeing the world, in effect. When you study a language in the field, you do so as a big baby. Like a baby, and like a drowning person, you hungrily seize new linguistic data and associate it with what you know. Only, unlike a baby, you are contaminated with one or more native languages, whose grasp upon the mind is fiercely jealous, blocking your view of any other language system. So if you come to understand your field language primarily in terms of your linguistic knowledge, the overwhelming influence of your native language inevitably wins, no matter how good a field worker you are. For the most part perhaps, it does not matter since the greater part of any language is universal grammar, or so we think. But it is a mistake to be too sanguine about this. We cannot easily avoid mistakes.”
An OT view of life

An interesting quote:

Quote from the book entitled *The language of God*, written by Francis S. Collins, 2006, New York, Simon & Schuster. He is a medical doctor and was the head of the Human Genome Project which deciphered the pattern of human DNA, and is a professing Christian.

In a section entitled “What Role Should Faith Play in Bioethical Debates?”, p. 244, he says the following:

“Basic principles of ethics can be derived from the Moral Law, and are universal. But conflicts can arise in a situation where not all of the principles can be satisfied at the same time, and different observers attach different weights to the principles that must be somehow balanced.”

******************************************************************************

Another very interesting and important quote, albeit on a different topic:

“But if we try to formalize this [a rule affecting laterals in Georgian], how general/concise should we make the rule? Should it be stated to apply before [−back] or before [−back, −low] vowels? How could we possibly decide? No empirical language-internal evidence can tell us, since the language has no [−back] vowels that aren’t [−low], so we have to rely on what a principled learning algorithm will tell us. Another relevant question is ‘Why do we care?’ The answer is that we get paid to care – phonologists are supposed to explain the nature and content of phonological knowledge, a matter of ‘individual psychology’, as we argued in Chapter 1” (Hale and Reiss 2008:95-96).

The nature of an OT grammar

For a given input, GEN, the generator, creates a candidate set of potential outputs. From the candidate set, EVAL, the evaluator, selects the best (optimal) output for each input.

GENerator

UG (universal grammar) includes a function GEN, which creates outputs.

1. GEN is not restricted to forms related to the input (GEN is quite creative).

2. GEN notes correspondence between input and output elements, known as Faithfulness (e.g., 
   PARSE and DEP).

CONstraints, a universal set

UG includes a set of constraints, CON, which is used to evaluate the candidate set.

Two main types of constraints:

1. Faithfulness (don’t delete; don’t insert; don’t change anything)

2. Structural
   A. Alignment (Left-to-Right vs. R-to-L parsing)
   B. Markedness (voiced obstruents are bad; front vowels prefer not to be rounded, etc.)

Three important properties of constraints:

- They encode markedness directly into the model (in contrast to previous approaches).
- Constraints are universal; all languages have access to exactly the same set of constraints.
- Constraints may conflict with each other — resolving this involves violating some constraints. That is, constraints are not infallible. This leads to variation between languages.

EVALuation, constraint ranking and violation

- The constraints in CON are violable.
- The constraints are ranked (on a language-particular basis).
• The optimal output is the one which best satisfies the ranked constraints, determined by EVAL.

- Violation of a lower ranked constraint may be tolerated in order to satisfy a higher ranked constraint.

- Ties (by violation or by satisfaction) of a higher ranked constraint are resolved by a lower ranked constraint.

• A chart called a tableau is used to prove which candidate is top ranked.

Tips on reading tableaux:

1. top row: input and constraints
   a. constraints are ranked left to right
   b. highest ranked constraints are at the left; lowest ranked constraints are at the right
   c. if constraints are unranked with respect to each other, a dotted or dashed line separates them
2. leftmost column: partial candidate set of outputs created by GEN (not a total set [infinite]; just the most likely candidates are considered)
3. optimal candidate by EVAL is indicated by “□” in the leftmost column
4. violations of constraints are marked with an asterisk, *, in the appropriate cell
   a. an exclamation point, !, indicates a fatal violation
   b. shaded cells show irrelevant constraints: the optimal form has already been decided
   c. multiple *’s in a cell indicate multiple violations: these are gradient constraints

Summary

How OT works:

1. UG includes
   a. A linguistic alphabet
   b. A set of constraints (CON)
   c. Two functions, GEN and EVAL
2. The grammar of a particular language includes
   a. Basic forms for morphemes (from which inputs are constructed)
   b. A ranking for the constraints in CON
3. For each input,
   a. GEN creates a candidate set of potential outputs
   b. EVAL selects the optimal candidate from that set

How OT addresses the issues that concern linguists:

1. Language variation is characterized as different rankings of the same set of constraints.
2. OT predicts that specific patterns are derived from the rankings of these constraints.
3. Universals are present in the innate and universal — but violable — constraints. This resolves a long-standing frustration with the notion of universals: they don’t play the same role in every language.

4. Markedness is inherent in the model.
   a. Each constraint is a markedness statement.
   b. Specific aspects of markedness result from the ranking.

******************************************************************************

Main theses of OT:

Liberation Thesis: constraints must be liberated from the parochial rule package.

Output-Orientation Thesis: what’s crucial to determining a process is often not an input configuration but rather an output configuration that must be achieved.

Inventory Thesis: there are no lexicon-specific constraints. (Rather, the constraints of phonology induce structure on the Lexicon indirectly.)

Interaction Thesis: variation lies not in the constraints themselves (“parameterization”), but in their possibilities of interaction.

Basic premises of OT:

1. Grammar is defined by the interaction of constraints.
2. Constraints come in two kinds:
   a. Markedness constraints evaluate output representations.
   b. Faithfulness constraints demand that input and output must be identical in a certain way.
3. Constraints may conflict with each other over the relative value of representations.
4. Even so, all constraints are present in every grammar (language).
5. Constraints are violable: conflicts are decided by prioritization (ranking).
6. Even so, constraint violation is minimal.
7. Differences between grammars are precisely differences in their prioritization schemes.
8. Each input gives rise to a set of potential outputs, a candidate set.
   a. This candidate set is the same for all grammars.
   b. The candidate that best satisfies the ranked constraint set (in a particular language) is output for the given input.

Architecture of OT:

UG provides:

CON, the set of universal constraints present in every grammar
GEN, the function determining the candidate set for each input
EVAL, the mechanism by which the candidate set is evaluated, for a given ranking of CON
Language-particular variation is obtained through variation in ranking, not through altering the constraints themselves.

Principles of OT:

1. Violability: constraints are violable, but violation is minimal.

2. Ranking: constraints are ranked on a language-particular basis. The notion of minimal violation is defined in terms of ranking.

3. Inclusiveness: the constraint hierarchy evaluates a set of candidate analyses that are admitted by very general considerations of structural well-formedness.

Within OT, the role of a grammar is to select the output form from among a very wide range of candidates, including at least all of the outputs that would be possible in any (human) language whatsoever. Thus, language-particular rules or procedures for creating representations have no role at all in the theory, and the entire burden of accounting for the specific patterns of individual languages falls on the well-formedness constraints. These constraints are ranked in a language-particular hierarchy; any constraint is violated, minimally, if such violation leads to the satisfaction of a higher-ranked constraint.

References


-Rutgers Optimality Archive (ROA)

An electronic repository for manuscripts, papers, books, dissertations, etc. dealing with OT. Currently it contains over 1140 entries, dating back to its inception in 1993. You can search by title, author, abstract, keywords, entry number, etc. Many important published works on OT began their life in a more rough form on the ROA. Its URL is http://roa.rutgers.edu/index.php3.

-Textbooks


McCarthy, John J. 2002. *A thematic guide to optimality theory*. Research Surveys in Linguistics. Cambridge: Cambridge University Press. (This is quite technical and can be heavy reading.)


-Journals

The following journals are the most important ones that publish articles on OT, although not exclusively:

*Language*

*Linguistic Inquiry*

*Natural Language and Linguistic Theory*

*Phonology*

-Collections / Anthologies


mini-encyclopedia focused just on phonology. Over 3100 pages. Does not deal just with
OT but rather has a more eclectic orientation.)

-Series

_Papers in optimality theory I-III (University of Massachusetts occasional papers in linguistics)_.
Amherst: Graduate Linguistic Student Association (GLSA).

-Software

“OTSoft is a Windows program meant to facilitate analysis in Optimality Theory by using
algorithms to do tasks that are too large or complex to be done reliably by hand. It is also meant
to save time and effort, particularly in word-processing.” Its URL is
http://www.linguistics.ucla.edu/people/hayes/otsoft/.

“This tutorial describes how you can draw Optimality-Theoretic and Harmonic-Grammar
tableaus and simulate Optimality-Theoretic and Harmonic-Grammar learning with PRAAT” (a
popular acoustic phonetics package, available for free download from the internet).

-Constraint Catalogue

Ashley, Karen C., Lynette Disch, David C. Ford, Erin MacSaveny, Steve Parker, Carla Unseth,
Angela M. Williams, Rachel Wong & Brendon Yoder. 2010. How many constraints are
there? A preliminary inventory of OT phonological constraints. GIAL Occasional Papers
documenting 1666 unique OT phonological constraints. These are taken primarily from
the four journals listed above, ranging between 1993-2008. Includes an instructional
paper describing how to use the catalogue, as well as a statistical summary of the results.
Also available on the ROA as item no. 1079.)

-Overview Papers

McCarthy, John J. 2007. What is Optimality Theory? _Language & Linguistics Compass_ 1:260-
91. (This is perhaps the best single summary of OT in an article length format. It includes
answers to some frequently asked questions about OT. _Language & Linguistics Compass_
(LLC) is a relatively new internet-only journal. It does not come out in hard copy form.
Furthermore, it does not accept open submissions, but works on a strictly invitation-only
basis.)

brief summary of the architecture, claims, predictions, consequences, and challenges for
OT in an encyclopedic type of format.)
Final paper

For the second half of this course you will be writing a paper rather than taking a final exam. The goal is a relatively short paper in the range of 8-10 pages, double-spaced (including notes and bibliography). The general criterion is to analyze a set of data using Optimality Theory. I am not expecting you to come up with any earthshaking theoretical innovations. Rather, you should aim for a description of a particular language using the tools of OT. A possible sub-theme is to compare and contrast the OT analysis with a non-OT treatment of the same facts and argue which of the two approaches is superior.

If you want to use your own data, that is great. If you don’t already have a language in mind, there are many good sources of data available. One is the Kenstowicz textbook itself, especially the problem sets. Another possibility is the book Generative Phonology by Kenstowicz and Kisseberth (1979). Also consider linguistic journals such as the International Journal of American Linguistics. The latter is rich in data and non-OT analyses.

There is no specific style required in the body of the paper or the notes. The important thing is just to be consistent, and helpful to the reader. But in the default case you should try to follow the GIAL Style Sheet when possible. This roughly follows the Unified Style Sheet for Linguistics Journals, available (among other places) from the following URL: http://linguistlist.org/pubs/tocs/index.cfm.

The final drafts of the paper are due on Day 41 at 5:00 pm. However, you should be in communication with me well before then. Everyone should consult with me at least once, when you are deciding about your topic. I may be able to give you some suggestions and references that will save you a lot of time. In addition, you are welcome to discuss your progress with me as often as you like.

Everyone will also present the results of their research, briefly, to the rest of the class. This will take place on the penultimate day of classes (Day 39). Given the size of our class, each student will have about 5 minutes maximum for their presentation. You may want to prepare an overhead slide or handout for this. This presentation will help you get peer feedback to refine your analysis and polish your work for the final draft.

Suggested outline:

In the abstract and/or first section (introduction), try to provide a clear answer to the following questions. This will enhance the readability and importance of your paper. Then in the body, address each of these issues in detail, more or less in this order. Finally, in the conclusion, review this list of questions, focusing on the answers you have provided.

1. What is the problem?
2. Why should we care about it?
3. What do I propose as my solution to the problem?
4. How is this better than all current approaches?
5. What claims, predictions, and implications does my analysis entail that go beyond just the topic I am focusing on here?
6. What problems and weaknesses could a skeptic use to argue against my approach?
7. What types of additional facts or data, if they existed, would help to either confirm or falsify my hypothesis?
Generalized Alignment


The theory of Generalized Alignment has the following structure for constraints (precursors in Selkirk 1986, Prince and Smolensky 1991 and 1993, Itô and Mester 1993):

\[
\text{Align (Category 1, Edge 1, Category 2, Edge 2)} = \text{def} \\
\forall \text{ Category 1} \exists \text{ Category 2 such that Edge 1 of Category 1 and Edge 2 of Category 2 coincide.}
\]

Where

\[
\text{Category 1, Category 2} \in \text{Prosodic Categories } \cup \text{ Grammatical Categories}
\]

\[
\text{Edge 1, Edge 2} \in \{ \text{Right, Left} \}
\]

\(\forall\) = universal quantifier, i.e., for every or all \(x\)

\(\exists\) = existential quantifier, i.e., there is some \(x\)

\(\in\) = is a member or element of

\(\cup\) = the union of two sets

Example:

\text{ALLFEETLEFT (AFL): Align(Ft, L, PrWd, L): The left edge of every foot must be aligned with the left edge of some Prosodic Word.}

If AFL \(\gg\) PARSESYLLABLE, the result is non-iterative parsing:

(1)

<table>
<thead>
<tr>
<th>Input: /σσσσσσ/</th>
<th>ALLFEETLEFT</th>
<th>PARSESYLLABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (σσ)(σσ)(σσ)</td>
<td><em>!</em>, ****</td>
<td></td>
</tr>
<tr>
<td>b. σσσσσσσσσσ</td>
<td></td>
<td>****</td>
</tr>
</tbody>
</table>

In order to derive iterative (exhaustive) footing, we need PARSESYLLABLE to outrank AFL (or AFR):
\(\text{(2)}\)

<table>
<thead>
<tr>
<th>Input: /σσσσσσσ/</th>
<th>ParseSyllable</th>
<th>AllFeetLeft</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (\tilde{\text{σ}})((\tilde{\text{σ}}))((\tilde{\text{σ}}))</td>
<td>(<strong>,</strong>)</td>
<td>!****</td>
</tr>
<tr>
<td>b. (\text{σ}(\text{σ})\text{σ})σ</td>
<td>(***)</td>
<td>!****</td>
</tr>
</tbody>
</table>

\text{AllFeetLeft} \rightarrow \text{AllFeetRight} \text{ gives us directional footing:} \(\text{(3)}\)

<table>
<thead>
<tr>
<th>Input: /σσσσσσσσ/</th>
<th>AllFeetLeft</th>
<th>AllFeetRight</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (\tilde{\text{σ}})((\tilde{\text{σ}}))((\tilde{\text{σ}}))((\tilde{\text{σ}}))</td>
<td>(<strong>,</strong>)</td>
<td>9*</td>
</tr>
<tr>
<td>b. (\text{σ}(\text{σ})\text{σ}(\text{σ})\text{σ})</td>
<td>(*<strong>,</strong>)</td>
<td>6*</td>
</tr>
</tbody>
</table>

If \text{MainRight} \rightarrow \text{MainLeft}, primary stress will be on the final foot: \(\text{(4)}\)

<table>
<thead>
<tr>
<th>Input: /σσσσσσσσ/</th>
<th>MainRight</th>
<th>MainLeft</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (\text{σ}(\text{σ})\text{σ}(\text{σ})\text{σ})</td>
<td>!****</td>
<td>****</td>
</tr>
<tr>
<td>b. (\tilde{\text{σ}})((\tilde{\text{σ}}))((\tilde{\text{σ}}))((\tilde{\text{σ}}))</td>
<td>!****</td>
<td>****</td>
</tr>
</tbody>
</table>

In order to achieve the effect of extrametricality, \text{NonFinality} must dominate the appropriate alignment constraint: \(\text{(5)}\)

<table>
<thead>
<tr>
<th>Input: /σσσσσσσσ/</th>
<th>NonFinality</th>
<th>ParseSyllable</th>
<th>AllFeetRight</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (\text{σ}(\text{σ})\text{σ}(\text{σ})\text{σ})</td>
<td>!</td>
<td>(<strong>,</strong>)</td>
<td>!****</td>
</tr>
<tr>
<td>b. (\tilde{\text{σ}})((\tilde{\text{σ}}))((\tilde{\text{σ}}))((\tilde{\text{σ}}))</td>
<td>**</td>
<td>*</td>
<td>**</td>
</tr>
<tr>
<td>c. (\text{σ}(\text{σ})\text{σ}(\text{σ})\text{σ})</td>
<td>**<em>!</em></td>
<td>*</td>
<td>!</td>
</tr>
</tbody>
</table>

If \text{FootBinarity} \rightarrow \text{ParseSyllable}, then left over lone syllables will not be parsed into degenerate feet: \(\text{(6)}\)

<table>
<thead>
<tr>
<th>Input: /σσσσσσσσ/</th>
<th>FootBinarity</th>
<th>ParseSyllable</th>
<th>AllFeetRight</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (\text{σ}(\text{σ})\text{σ}(\text{σ})\text{σ})</td>
<td>!</td>
<td>12*</td>
<td></td>
</tr>
<tr>
<td>b. (\tilde{\text{σ}})((\tilde{\text{σ}}))((\tilde{\text{σ}}))((\tilde{\text{σ}}))</td>
<td>*</td>
<td>6*</td>
<td></td>
</tr>
<tr>
<td>c. (\text{σ}(\text{σ})\text{σ}(\text{σ})\text{σ})</td>
<td><strong>!</strong>***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Your written homework to turn in on Day 28 consists of the following two problem sets (one of which is on the back side of this sheet):

(A) Maori exercise

In the following data there is an overt morphophonemic alternation taking place. State the descriptive generalization of the process in prose (in your own words). Then account for it using OT constraints. Give two tableaux, one for each of two words: [wero], and [werohaŋa]. You do not need to worry about any other aspects of these data; just deal with the alternation you observe. You should be able to do this with constraints we have already talked about together in class.

<table>
<thead>
<tr>
<th>active</th>
<th>passive</th>
<th>gerundive</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>wero</td>
<td>werohia</td>
<td>werohaŋa</td>
<td>‘stab’</td>
</tr>
<tr>
<td>hopu</td>
<td>hopukia</td>
<td>hopukaŋa</td>
<td>‘catch’</td>
</tr>
<tr>
<td>aru</td>
<td>arumia</td>
<td>arumaŋa</td>
<td>‘follow’</td>
</tr>
<tr>
<td>mau</td>
<td>mauria</td>
<td>mauраŋa</td>
<td>‘carry’</td>
</tr>
<tr>
<td>afi</td>
<td>afitia</td>
<td>afitaŋa</td>
<td>‘embrace’</td>
</tr>
</tbody>
</table>

Note: if you are typing up this homework (which is not required, but may be convenient for you), you can obtain the symbol for the velar nasal /ŋ/ in Word by using the commands “Insert” followed by “Symbol”. Then just look for this character in the font you are using. If that does not work, just substitute an “m” for the “ŋ” in the appropriate Maori data that you refer to, with a note to that effect.

Sources of data:


(B) Hypothetical rankings

Below are three different hypothetical languages, each one with potentially distinct rankings. In each case we are considering two different output candidates (whose segmental make up is irrelevant). In each case there are also two or three relevant constraints, whose definition does not matter. Assume these constraints are listed below in random order. The evaluation of each candidate on each constraint is given below (* = violates and ✓ = satisfies). In each of these three situations (languages), candidate a is the winner, i.e., we need it to defeat candidate b. Based on these facts, we are trying to determine the crucial rankings of the constraints for each language. Your homework partner makes the following claim: in each of these three languages, we can and must conclude that Constraint 1 crucially dominates or outranks Constraint 2. In other words, Constraint 1 » Constraint 2. Is this conclusion justified (true)? Explain why or why not for each of the three cases (languages).

**Language 1:**

<table>
<thead>
<tr>
<th>Constraint 1</th>
<th>Constraint 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Candidate a</td>
<td>✓</td>
</tr>
<tr>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constraint 1</th>
<th>Constraint 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Candidate b</td>
<td>✓</td>
</tr>
<tr>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Language 2:**

<table>
<thead>
<tr>
<th>Constraint 1</th>
<th>Constraint 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>*</td>
</tr>
<tr>
<td>Candidate a</td>
<td>✓</td>
</tr>
<tr>
<td>✓</td>
<td>*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constraint 1</th>
<th>Constraint 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>*</td>
</tr>
<tr>
<td>Candidate b</td>
<td>✓</td>
</tr>
<tr>
<td>✓</td>
<td>*</td>
</tr>
</tbody>
</table>

**Language 3:**

<table>
<thead>
<tr>
<th>Constraint 1</th>
<th>Constraint 2</th>
<th>Constraint 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>*</td>
<td>✓</td>
</tr>
<tr>
<td>Candidate a</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constraint 1</th>
<th>Constraint 2</th>
<th>Constraint 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Candidate b</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Source:

Continuation of Generalized Alignment

Axininca Campa (Peru)

(1) onset epenthesis

|----------------|--------------|-----------------|------------------|------------------------|--------------|-----------------|------------------|------------------------|

(2)

<table>
<thead>
<tr>
<th>Input: /i-N-koma-i/</th>
<th>ONSET</th>
<th>DEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [iŋ.ko.ma.Ti]</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b. [iŋ.ko.ma.i]</td>
<td>**!</td>
<td></td>
</tr>
</tbody>
</table>

(3) Descriptive generalization: Axininca Campa has no word-initial epenthesis and freely tolerates initial onsetless syllables.

(4) “NOHIATUS” (hypothetical brute-force constraint, parameterizing ONSET)

*\text{σ}[^V_{\text{except word-initially}}]

(5) A better solution:

ALIGNLEFT: Align(Grammatical Word, L, PrWd, L)

“The left edge of every Grammatical Word coincides with the left edge of some Prosodic Word.”
(6) Failure of Prothesis:

<table>
<thead>
<tr>
<th>Input: /i-N-koma-i/</th>
<th>ALIGNLEFT</th>
<th>ONSET</th>
<th>DEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [iŋ.ko.ma.i]</td>
<td></td>
<td>**!</td>
<td></td>
</tr>
<tr>
<td>b. [iŋ.ko.ma.Ti]</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c. [T'iŋ.ko.ma.Ti]</td>
<td></td>
<td>!</td>
<td>**</td>
</tr>
</tbody>
</table>

(7) Stem-syllable alignment:

```
/i-N-koma-i/ → [iŋ.ko.ma.|Ti]
*iŋ.ko.ma|i*
```
```
/i-N-koma-ako-i/ → [iŋ.ko.ma.|Ta.ko.|Ti]
*iŋ.ko.ma|a.ko|i*
```

(8) ALIGNRIGHT: Align(Stem, R, σ, R)

“The right edge of every Stem coincides with the right edge of some syllable.”

(9)

<table>
<thead>
<tr>
<th>Input: /i-N-koma-i/</th>
<th>ALIGNRIGHT</th>
<th>DEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [iŋ.ko.ma.</td>
<td>Ti]</td>
<td></td>
</tr>
<tr>
<td>b. [iŋ.ko.ma</td>
<td>i]</td>
<td>!</td>
</tr>
</tbody>
</table>

(10) ALIGNLEFT: Align(T, L, PrWd, L)

“The left edge of every Tone coincides with the left edge of some Prosodic Word.”

(11)

<table>
<thead>
<tr>
<th>Input: /σσσ, HL/</th>
<th>NoContour</th>
<th>NoFloat</th>
<th>ALIGNLEFT</th>
<th>NoSpread</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. σ σ σ</td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b. σ σ σ</td>
<td></td>
<td></td>
<td>**!</td>
<td>*</td>
</tr>
<tr>
<td>c. σ σ σ</td>
<td>!</td>
<td></td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>d. σ σ σ</td>
<td></td>
<td><em>!</em>****</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Child language acquisition problem

Your written homework to turn in on Day 29 consists of the following exercise.

OT accounts for child language acquisition in the same way that it accounts for adult speech: by a language-specific ranking of the same set of innate but violable constraints. Consider the simplified data below from a girl two years and nine months old learning American English:

<table>
<thead>
<tr>
<th>Adult</th>
<th>Child</th>
</tr>
</thead>
<tbody>
<tr>
<td>clean</td>
<td>[kin]</td>
</tr>
<tr>
<td>friend</td>
<td>[fen]</td>
</tr>
<tr>
<td>please</td>
<td>[piz]</td>
</tr>
<tr>
<td>skin</td>
<td>[kin]</td>
</tr>
<tr>
<td>sky</td>
<td>[kaj]</td>
</tr>
<tr>
<td>sleep</td>
<td>[sip]</td>
</tr>
<tr>
<td>slip</td>
<td>[sip]</td>
</tr>
<tr>
<td>snookie</td>
<td>[suki]</td>
</tr>
<tr>
<td>snow</td>
<td>[so]</td>
</tr>
<tr>
<td>spill</td>
<td>[ptw]</td>
</tr>
<tr>
<td>spoon</td>
<td>[pun]</td>
</tr>
<tr>
<td>star</td>
<td>[ta:]</td>
</tr>
</tbody>
</table>

Sources of data:


McCarthy, John J. 2008. Doing optimality theory: Applying theory to data. Malden, Massachusetts: Blackwell. [McCarthy actually transcribes this child’s pronunciation of words like skin as [gin] rather than [kin]. He then comments (p. 233): “Because plosives in [s] clusters are voiceless and unaspirated, they are identical to English ‘voiced’ plosives, which are also usually voiceless and unaspirated word-initially. Thus, there is no actual difference between the adult pronunciation of orthographic k in skin and the [g] transcription in the child’s pronunciation.”]

Your task is to come up with an OT explanation for which of the two onset consonants “deletes” in this child’s speech. State the phonological generalization in prose. Consider the adult forms to be the inputs of each corresponding child output form. The markedness constraint driving cluster simplification is the following:
*COMPLEX: Onset clusters are prohibited in output forms. (*_{0}(CC))

Besides deletion, consonant clusters in theory could also be repaired by inserting an intervening vowel: hypothetical /sno/ → [sono]. You may ignore this possibility for the purposes of this assignment, assuming that it would be blocked by ranking DEP high in this grammar. Also, some of the markedness constraints could be better satisfied by changing consonants, e.g., hypothetical /sno/ → [to]. This would be blocked by high-ranking featural faithfulness constraints such as IDENT(continuant), etc., i.e., Don’t change a sound from [−cont] to [+cont], and vice-versa. You can ignore these types of candidates as well. (IDENT(feature) constraints are necessary to prevent every word in every language from changing to [tata], etc.) All you need to account for in this problem is the correct deletion of certain onset consonants. So don’t worry about the deletion or change in coda consonants, etc.

Besides *COMPLEX above, your analysis should also include the following constraints (only these, and no others):

*ONSET/nasal  Abbreviated as *ONS/n. Defined as “An onset consonant cannot be a nasal.”
*ONSET/stop   Abbreviated as *ONS/t. Defined in an analogous way, etc.
MAX         Segmental deletion is prohibited.
*ONSET/liquid Abbreviated as *ONS/l.
*ONSET/fricative Abbreviated as *ONS/s.

For constraints like *ONSET/nasal, we may assume that they rule out nasal consonants regardless of whether they occur alone (by themselves) in the onset, or as part of a syllable-initial cluster. In other words, output candidates such as [sna], [na], and [nwa] all violate *ONSET/nasal equally — one time each.

Your task is to determine the correct ranking of these six constraints for describing this girl’s speech. Give a ranking summary of the constraints. Also, give three tableaux: one for the word spoon, another one for the word clean, and the third one for the word snow. In the first tableau, limit your consideration to the following set of candidates: [spun] (fully faithful), [sun], [pun], and [un]. For the second tableau, consider the analogous candidate set: [klin], [kin], [lin], and [in]. For the third tableau, think up for yourself what are the best (most appropriate) candidates to include.

Optional/extra credit: When my son Jayden was one year and seven months old, he pronounced the word snack as [næk]. In other words, he deleted the underlying /s/. The grammar of the girl above could not produce this result; presumably she would pronounce this word differently, as [sæk]. In order to account for Jayden’s speech, we would need to do one of two things: either permute (rerank) the constraints, or invoke some other constraint. One constraint that would work for Jayden is a high ranking prohibition against all fricatives, since he didn’t produce any of them at that time. Such a markedness constraint might be called simply *FRICATIVE. Informally, and somewhat humorously, we could define this as “Don’t be a fricative.” More formally it would be defined as “Fricatives are prohibited in output forms.” And even more
technically, it would be stated in featural terms: “The feature [+continuant] is prohibited in output forms” (at least among obstruents). But there is another way to compel the mapping of /snæk/ → [næk], this time with a **faithfulness** constraint. Can you think of what such a constraint might say or do, and why it might exist? In other words, for other (adult) speakers of other languages, what might be a real situation (phonological phenomenon) for which such a faithfulness constraint needs to be invoked? Note that for the purposes of this extra credit, you don’t need to rule out all fricatives, just those that are the initial consonant in an onset cluster.
The Correspondence Theory of faithfulness


Given two strings of phonological elements $S_1$ and $S_2$, *correspondence* is a relation $\mathcal{R}$ from the elements of $S_1$ to those of $S_2$. Elements $\alpha \in S_1$ and $\beta \in S_2$ are referred to as *correspondents* of one another when $\alpha \mathcal{R} \beta$.

**Constraints on correspondent elements**

1. **The MAX constraint family** (anti-deletion; replaces PARSE)

   **General schema:**
   
   Every segment of $S_1$ has a correspondent in $S_2$.

   **Specific instantiations:**
   
   - MAX-IO (input-output)
     
     Every segment of the Input has a correspondent in the Output.
     (No phonological deletion.)
   
   - MAX-BR (base-reduplicant)
     
     Every segment of the Base has a correspondent in the Reduplicant.
     (Reduplication is total.)

2. **The DEP constraint family** (anti-epenthesis; replaces FILL)

   **General schema:**
   
   Every segment of $S_2$ has a correspondent in $S_1$.
   ($S_2$ is “dependent on” $S_1$.)

   **Specific instantiations:**
DEP-IO

Every segment of the Output has a correspondent in the Input.
(No phonological epenthesis.)

DEP-BR

Every segment of the Reduplicant has a correspondent in the Base.
(Prohibits fixed default segmentism in the Reduplicant.)

(3) The IDENT(Feature) constraint family

General schema:

IDENT(F)

Let $\alpha$ be a segment in $S_1$ and $\beta$ be any correspondent of $\alpha$ in $S_2$. 
If $\alpha$ is $[\gamma F]$, then $\beta$ is $[\gamma F]$.
(Correspondent segments are identical in feature F.)

Specific instantiations:

IDENT-IO(F)

Output correspondents of an Input $[\gamma F]$ segment are also $[\gamma F]$.

IDENT-BR(F)

Reduplicant correspondents of a Base $[\gamma F]$ segment are also $[\gamma F]$.

(4) LINEARITY (No metathesis)

The Input is consistent with the precedence structure of the Output, and vice versa.
(Do not permute the order of correspondent segments.)

(5) CONTIGUITY

I-CONTIGUITY (No skipping)

The portion of the Input standing in correspondence forms a contiguous string.
(Favors peripheral deletion.)
O-CONTIGUITY (No intrusion)

The portion of the Output standing in correspondence forms a contiguous string. (Favors peripheral epenthesis.)

(6) UNIFORMITY (No coalescence)

No element of the Output has more than one correspondent in the Input.

(7) INTEGRITY (No breaking or diphthongization)

No element of the Input has multiple correspondents in the Output.

(8) {Right, Left}-ANCHOR (Basically like ALIGN)

Any element at the right/left edge of the Input has a correspondent at (respectively) the right/left edge of the Output.

(9) Hypothetical illustrations:

Some I-O correspondents: Input = /p a u k t a /

[p a u k t a ] A fully faithful mapping: perfect I-O correspondence.

[p a ? u k t a ] Hiatus prohibited (by high-ranking ONSET), so epenthetic [?] in O has no correspondent in I.

[p u k t a ] Hiatus prohibited, leading to V deletion. The segment /a/ in I has no correspondent in O.

[p a u t a ] The /k/ in I has a non-identical correspondent in O, for phonological reasons.

[p a k u t a ] Hiatus prohibited, leading to reversal of order between two correspondent segments.

[b l u r k] No element of O stands in correspondence with any element in I. Typically fatal.

Some B-R correspondents: Input = /RED + badupi/

[b a d u p i ] Total reduplication: perfect B-R correspondence.
Partial reduplication: /upi/ in B has no correspondents in R.

The [?] in R is not in correspondence with the /b/ in the Base. This is fixed-segment reduplication.

The [?] in R has a non-identical correspondent in B. This and the preceding candidate are formally distinct [although not phonetically distinct], since EVAL considers candidates along with their correspondence relations.

Some common misconceptions about Optimality Theory:

1. OT requires that deleted segments be present but syllabically unparsed (Containment Theory).
2. OT cannot deal with floating tones or empty segments.
3. OT is a theory of prosody only and has nothing to say about segmental phonology.
4. OT is incompatible with (or is only compatible with) moraic prosody.
5. OT denies the possibility of distinct lexical and postlexical phonologies (i.e., it is incompatible with Lexical Phonology).
6. OT says that morphology can impinge on phonology only at constituent edges, through alignment.
7. OT is inherently non-derivational.
8. OT is a theory of phonology only, without relevance to morphology or syntax.
9. OT has discarded (to its detriment) all the insights of feature geometry / skeletal theory / metrical theory / etc.
10. If OT is correct, then the optimal output form for any input form in any language should be [tatata...] (the Fallacy of Perfection).

“How could any of these things be true of necessity, when what OT says is that grammars are defined by constraint hierarchies? These issues have their place in the context of evaluating particular theories of phonology embedded within OT, but there is no such thing as a ‘standard OT’ account of any of them nor, I think, could there ever be one.”

Your written homework assignment to turn in on Day 31 is to develop an OT account of stress patterns in Chamicuro. The data appear on a previous handout. To remind you of the basic facts, primary stress always falls on the penultimate syllable, and secondary stress on every other second preceding syllable. In terms of the metrical grid approach of Halle and Vergnaud (1987), the following parameter settings are in effect:

stressable element: syllable
direction of parsing: right-to-left (on line 0)
headedness: left-headed (trochaic, on line 0; right-headed on line 1)
quantity-sensitivity: off (so the feet are syllabic trochees)
extrametricality: off
clash removal: on
line conflation: off

In OT terms the most relevant constraints which you need to consider are the following:

**Foot Binarity (FTBIN):** Feet consist of two syllables.

**Trochaic (TROCH):** Feet are left-headed: \([\sigma^s (\sigma^w)]_{Ft}\)

**Iambic (IAMB):** Feet are right-headed: \([ (\sigma^w) \sigma^s]_{Ft}\)

**All Feet Left (AFL):** ALIGN(Ft, L, PrWd, L): The left edge of every foot must be aligned with the left edge of some Prosodic Word.

**All Feet Right (AFR):** ALIGN(Ft, R, PrWd, R): The right edge of every foot must be aligned with the right edge of some Prosodic Word.

**Main Left (MNLFT):** ALIGN(Head Foot, L, PrWd, L): The left edge of every main stress foot must be aligned with the left edge of some Prosodic Word.

**Main Right (MNRT):** ALIGN(Head Foot, R, PrWd, R): The right edge of every main stress foot must be aligned with the right edge of some Prosodic Word.
**NonFinality (NONFIN):** The final syllable (or stress bearing unit) of the word is not contained within a metrical foot.

**Parse Syllable (PARSESYL):** Every syllable belongs to some foot.

The most crucial ranking interactions involve the following pairs of constraints:

- **FTBIN** vs. **PARSESYL**
- **TROCH** vs. **IAMB**
- **AFL** vs. **AFR**
- **AFR** vs. **PARSESYL**
- **MNLF** vs. **MNRT**
- **MNRT** vs. **NONFIN**

Choose a few carefully selected Chamicuro words and give tableaux for them, ruling out the most promising candidates. A word of caution: a parametric derivational model like that of Halle and Vergnaud does not necessarily translate directly into the OT framework. Things are conceived of differently in OT. For example, in OT it is no longer appropriate to speak of operations that “build or construct feet.” Rather, GEN supplies candidates with rich metrical structures; these forms are then “scanned” by the constraints to look for compliance or violation. Notice that the “foot form” constraints TROCHAIC and IAMBIC are violated once for each such constituent in an output candidate. For example, if a particular candidate contains three trochees, it violates IAMB three times. On the other hand, a degenerate (monosyllabic) foot automatically satisfies both TROCHEE and IAMB simultaneously. TROCH and IAMB are violated and/or satisfied the same regardless of whether a foot encodes primary stress or secondary stress. Be sure to include a pair of parentheses around each metrical foot in your output candidates. Also, give two summary (exhaustive) tableaux, each one containing all of the constraints simultaneously. Include one such tableau for a word containing an even number of syllables (let’s say six), and another tableau for a word containing seven syllables. Let us assume that all metrical feet must have heads. In other words, every foot must contain a stressed syllable. So in your output candidates, whenever you put a pair of parentheses around the segments contained in a foot, one of those syllables should be stressed (either primary or secondary). We might assume that GEN cannot output any metrical constituents (feet) that are unheaded (unstressed). Or maybe we want to enforce this with a violable constraint. For the purposes of this assignment, let us ignore this particular complication, and assign a head to all feet. Finally, you may wonder about situations of stress clash. There are OT constraints that prohibit these, i.e., they are violated when adjacent stress-bearing units are both stressed. In this exercise you can probably ignore this type of constraint since I think its effects can be produced through the interaction of PARSESYLLABLE and FOOTBINARITY.
Some basic constraints for analyzing tonal languages in Optimality Theory

(1) MAX(Tone)

Every tone in the Input has a correspondent in the Output.
“Do not delete underlying tones.”

Presumably this can be subcategorized for specific tones: MAX(High), MAX(Low), etc.

(2) DEP(Tone)

Every tone in the Output has a correspondent in the Input.
“Do not insert tones.”

(3) IDENT(Tone)

A segment (syllable, mora) in the Output is associated with the same tonal feature(s) as its correspondent in the Input.
“Do not change tonal specifications.”

(4) NoFLOATINGTONE

Every tone must be associated with some Tone Bearing Unit.

(5) NoTONELESSTBU

Every TBU must be associated with some tone.

(6) NoCONTOURTONE

\[ * \ T_1 \quad T_2 \]

\[ \sqrt{V} \]
Deriving the phonemic inventory of a language through constraint ranking

Suppose a tonal language is limited to two tones, High and Low. The inventory of contrastive tones can be restricted in the following way:

(12) *Mid » Max(Tone), Ident(Tone) » *High, *Low

This is necessary because of the Richness of the Base assumption (there are no language-specific restrictions on the lexicon). In other words, the set of possible inputs is infinite and must be dealt with through constraint ranking. Every conceivable input must have as its output a theoretically pronounceable (grammatically well-formed) word in a given language.

In a non-tonal language such as English, we would need the following ranking:

(13) *High, *Low, *Mid » Max(Tone), Ident(Tone)
This would ensure that no underlying tone could ever surface intact in an Output form. Intonation or pitch-accent would of course have to be allowed for in some way.

**Mende (a tonal melody language)**

kpá ‘debt’
mbû ‘owl’
ngílà ‘dog’
ndàvůlá ‘sling’

(14) \textsc{NoFloatingTone, NoTonelessTBU, Max(Tone)} \rightarrow \textsc{Ident(Tone)}

<table>
<thead>
<tr>
<th>/kpa, L/</th>
<th>NoFLT</th>
<th>NoTNL</th>
<th>Max(T)</th>
<th>NoSpr</th>
<th>NoCnt</th>
<th>AL(L)</th>
<th>AL(R)</th>
<th>ID(T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>σ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
</tr>
<tr>
<td>σ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
</tr>
</tbody>
</table>

(15) \textsc{NoFloatingTone, NoTonelessTBU} \rightarrow \textsc{NoContourTone}

<table>
<thead>
<tr>
<th>/mbu, HL/</th>
<th>NoFLT</th>
<th>NoTNL</th>
<th>Max(T)</th>
<th>NoSpr</th>
<th>NoCnt</th>
<th>AL(L)</th>
<th>AL(R)</th>
<th>ID(T)</th>
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</tbody>
</table>
(16) \textbf{NoSpreadTone, NoContourTone} » \textbf{AlignLeft}

<table>
<thead>
<tr>
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<th>NoTnl</th>
<th>Max(T)</th>
<th>NoSpr</th>
<th>NoCnt</th>
<th>Al(L)</th>
<th>Al(R)</th>
<th>Id(T)</th>
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<tbody>
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<td>b. H L [\frac{\sigma}{\sigma} \frac{\sigma}{\sigma}]</td>
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</table>

(17) \textbf{AlignLeft} » \textbf{AlignRight}

<table>
<thead>
<tr>
<th>/ndavula, LH/</th>
<th>NoFlt</th>
<th>NoTnl</th>
<th>Max(T)</th>
<th>NoSpr</th>
<th>NoCnt</th>
<th>Al(L)</th>
<th>Al(R)</th>
<th>Id(T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. L H [\frac{\sigma}{\sigma} \frac{\sigma}{\sigma} \frac{\sigma}{\sigma}]</td>
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<td></td>
<td>*</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>b. L H [\frac{\sigma}{\sigma} \frac{\sigma}{\sigma} \frac{\sigma}{\sigma}]</td>
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<td>c. L H [\frac{\sigma}{\sigma} \frac{\sigma}{\sigma} \frac{\sigma}{\sigma}]</td>
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<td>d. L H [\frac{\sigma}{\sigma} \frac{\sigma}{\sigma} \frac{\sigma}{\sigma}]</td>
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<td>e. L H [\frac{\sigma}{\sigma} \frac{\sigma}{\sigma} \frac{\sigma}{\sigma}]</td>
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<td>**!</td>
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</tr>
</tbody>
</table>
Some OT Constraints for Tone Analysis

Markedness constraints:

*Float: A tone must be associated with a TBU.
SpecifyT: A TBU must be associated with a tone.
NoContour: A TBU must be associated with at most one tone.
NoLongT: A tone may be associated with at most one TBU.
Align-Tone: Align the specified edge (L/R) of a tone span with the head or edge (L/R) of a prosodic or morphological unit.
OCP: Adjacent identical elements are prohibited.
NoGap: Multiply linked tones cannot skip TBU’s.
Local: Spread only to the adjacent element.

Faithfulness constraints:

Dep-T: No insertion of tones.
Max-T: No deletion of tones.
*Associate: No new association lines.
*Disassociate: No removal of association lines.
NoFusion: Separate underlying tones must stay separate.
Linearity: Preserve underlying linear order.

Richness of the Base and Lexicon Optimization

Richness of the Base (ROTB) is “the hypothesis that the free combination of linguistic primitives and the input are identical” (McCarthy 2002:68).

In other words, there are no language-specific restrictions on UR’s, no linguistically significant generalizations about the lexicon, no systematic gaps in lexical forms, no Morpheme Structure Constraints, no redundancy rules which hold of UR’s, etc. All of this follows from the basic premise of OT that constraints govern only surface forms, not input forms.

The base is the universal and infinite set of inputs, and in OT the grammar (language-specific ranking of CON) must do all the work of ruling out systematic gaps such as English *bnick, while still allowing for accidental gaps such as blick.

ROTB is a consequence of the thesis that the only difference between languages resides in their idiosyncratic ranking of the universal set of constraints (CON).

As a result of ROTB, a language-specific “inventory” must now be redefined as “the set of linguistic objects that are permitted in the output representations of a language” (McCarthy 2002:68).

One strong motivation for ROTB is that it avoids the so-called duplication problem, by which in some languages a prohibited segment or sequence is ruled out in the underlying phonemic inventory by a static lexical redundancy rule, and yet is still actively avoided during the course of the derivation in that rules which would otherwise produce it are blocked from applying (Structure Preservation).

Here’s an example of an inventory restriction produced indirectly by the interaction of constraints applying only to surface (output) forms. Take a language like English, which has no front rounded vowels:

(1)  *FRONT-ROUND: front vowels cannot be rounded.

(2)  IDENT(back): Output segments and their Input correspondents must agree in their values for the feature [back].

\[
\begin{array}{|c|c|c|}
\hline
\text{Input: /tük/} & \text{*FRONT-ROUND} & \text{IDENT(back)} \\
\hline
\text{a. [tük]} & *! &  \\
\hline
\text{b. [tuk]} & * &  \\
\hline
\end{array}
\]
Given (3), what is the actual, real UR for a word like [tuk]? It could conceivably be either /tuk/ or /tük/.

The principle of Lexicon Optimization (LO) was posited by Prince and Smolensky (1993) to deal with situations of this type (when the linguistic evidence runs out). LO says, all else being equal, posit the Input which has the most harmonic mapping.

(4) Tableau des tableaux:

<table>
<thead>
<tr>
<th>Inputs</th>
<th>*FRONT-ROUND</th>
<th>IDENT(back)</th>
</tr>
</thead>
<tbody>
<tr>
<td>/tük/</td>
<td>a. [tük]</td>
<td>*!</td>
</tr>
<tr>
<td></td>
<td>b. [tuk]</td>
<td>*</td>
</tr>
<tr>
<td>/tuk/</td>
<td>a. [tük]</td>
<td>*!</td>
</tr>
<tr>
<td></td>
<td>b. [tuk]</td>
<td>*</td>
</tr>
</tbody>
</table>

The mapping from /tuk/ to [tuk] incurs a proper subset of the violation marks of the mapping from /tük/ to [tuk], so /tuk/ is the Input which the language learner would select for the surface form [tuk]. In this sense the Input /tuk/ is said to occult (hide) the Input /tük/. Also, the mapping from /tük/ to [tuk] is harmonically bounded by the mapping from /tuk/ to [tuk], so the former cannot be a winner in this type of scenario.

Caveat: don’t expect LO to do any real work for you. It is only posited as a learning strategy, not a true grammatical principle. It corresponds to the claim that in the beginning state of the language learner, all markedness constraints outrank all faithfulness constraints. Thus, all outputs converge on unmarked forms. Learning and/or acquisition proceeds by demoting markedness constraints below the relevant (antagonistic) faithfulness constraints. So to reverse the ranking above, resulting in front rounded vowels in the output inventory, represents a complication and therefore corresponds to a more marked language (such as French).

There are several possible ways to empirically access (test) ROTB. The most common and important one is just morphological concatenation, i.e., putting morphemes together. In addition to this, we can appeal to the following areas of linguistic competence: (1) neologisms, (2) loanwords, (3) psycholinguistic experiments involving nonce forms, (4) speech errors like spoonerisms, (5) ludlings (word games), and (6) prior stages in the history of a language.

Here are a couple of illustrations of Richness of the Base:

- One guy somewhere in the U.S. wanted to have the last name in the local phone directory, so he legally changed his name to something like Zeke Zzzzzzzzypt. I read about this in the Guinness Book of World Records many years ago.

- Also, in Georgian the word meaning ‘he peels us’ is /gv-prckvnis/.

Reference:
The Advantages of OT

The following article lists a number of claimed advantages of OT compared with Rule-Based Phonology (RBP), such as the classical generative model and Lexical Phonology:


1. new directions, new empirical results (McCarthy and Prince 1993; McCarthy 2002)
2. generality of scope: OT can be applied not only to phonology, but also to syntax, semantics, etc. (McCarthy 2002)
3. parsimony: constraints only, not constraints plus rules plus other formal devices, so a more streamlined inventory of theoretical machinery. This is an application of Occam’s razor. (McCarthy 2002; Kager 1999)
4. direct incorporation of markedness (via universal constraints) (McCarthy and Prince 1993; Eckman 2005)
5. compatibility with connectionism: network-like grammars, typically using weighted or probabilistic constraints (Smolensky 1999; Dell et al. 1999; Seidenberg and MacDonald 1999)
6. factorial typology derives from free ranking (Féry and Fanselow 2002), calling attention to the problem of typological overkill or the Too Many Solutions/Repairs Problem (McCarthy 2002)
7. conspiracies: homogeneity of target / heterogeneity of process (McCarthy 1999; McCarthy and Prince 1993; Prince and Smolensky 1993)
8. Morpheme Structure Constraints (MSCs) and the problem of duplication or redundancy: rules and phonotactic constraints do the same thing, replicating each other’s purpose (Kager 1999)
9. problems with rules and levels: rules are inherently unconstrained, arbitrary, and language-specific; lexical strata or levels tend to be proliferated without independent justification (Ito and Mester 2003; McCarthy 2004)
10. grammaticality judgments and gradient well-formedness: these involve unsystematic nonce forms and indicate that speakers have knowledge about violated constraints; RBP cannot account for this (Steriade 2000, Hayes 2000, Coetzee 2004). In other words, experiments show that many speakers know things about their language which they could not have learned.

11. back-copying and overapplication in reduplication: faithfulness constraints can handle these well, but RBPs cannot deal with cases where the base copies from the reduplicant (McCarthy and Prince 1999). For example, some speakers of Pig Latin change “oven” into “woven-way”.

12. serial derivations, for one reason or another, do not make sense from a cognitive point of view (Orgun 1993, but see McCarthy 2006, 2007)

13. unifying the description of individual languages with cross-linguistic typology (through ranking permutation), may arguably be “the most important insight of the theory” (McCarthy 2002)

14. learnability: universal constraints make it much easier for the child to acquire a language (Zuraw 2004)

15. expressing structural descriptions (triggering environments) in addition to structural changes (repairs) with rules is more stipulative (Prince and Smolensky 1993, Lombardi 2001, Hayes 2004)

References


1. Introduction

The idea of doing phonology without rules may seem bizarre to those accustomed to rules and their sometimes complex interactions. But that is precisely what Optimality Theory does. Optimality Theory, or OT, was introduced in Prince & Smolensky (1993) and McCarthy & Prince (1993a, b). It has become the theory of choice for many American phonologists in the last several years, as shown by the many papers presented within the OT framework in recent conferences. In this paper, I will introduce the basic principles of Optimality Theory and compare it with a traditional generative theory that uses rules. My purpose here is not to give a comprehensive course in OT (this article by itself won’t equip you to use OT), but rather to give the rationale behind OT, how it works, and some of its strengths and current weaknesses. This article will serve as an introduction to the basic literature on OT, much of which is not easy reading at all.

Optimality Theory does away with rules in favor of constraints. Actually, constraints of various sorts have been used for quite a long time in phonology, alongside of rules. These constraints have ranged from morpheme structure constraints and the Obligatory Contour Principle, to various language-specific constraints. From past experience, it seems that rules by themselves are not enough; constraints of some sort are necessary. But given that we need constraints, are rules then necessary? The Optimality Theory approach says “No.” Russell (1997:110) compares constraints added to rules to band-aids applied to a patient, and adds “One might view Optimality Theory as the band-aids getting together, realizing their own power, and deciding they could get along quite nicely without the patient.” All things being equal (which they of course never are!) it is simpler to have a theory which has only constraints rather than constraints and rules.

Constraints within a rule-based theory are like rules in that they are unbreakable where they apply (with perhaps some lexical exceptions). However, constraints in Optimality Theory can be violated in the appropriate circumstances, since one constraint may push us in one direction, and another constraint may push us in a different direction. When two forces push in opposing directions, one generally proves stronger and “wins out.” In real life, I want to get a good night’s sleep, but I also want to finish a book I’m reading. I can’t do both; which desire wins? In phonology, I want to pronounce every consonant that a word contains, but I also want to have a CV syllable pattern, which is easier to pronounce. Often I can’t do both; which pattern wins? In Optimality Theory, any constraint can in principle be violated.

Another difference between rule-based approaches and Optimality Theory is that rules are usually assumed to apply in a particular order (“serially”), and this order is sometimes crucial. However, in OT, potential surface forms are scanned for violations of constraints, and how well constraints are satisfied is evaluated simultaneously for all constraints (“in parallel”). We can represent these two approaches as below.

---

1 Many thanks to friends and colleagues who read this manuscript for clarity and accuracy: Fraser Bennett, Rod Casali, Tsan Huang, S. A. Miller, Ken Olson, and Paul Thomas. Probably none of them is totally satisfied with the result, but it is a much better article for their input.

2 I ignore here the debates in the past on simultaneous vs. sequential application of rules, and what principles should govern the ordering of rules.
(1) **Rule-based schema - a derivation**

Underlying representation: /kænnat/ “cannot”
- Rule #1 applies: kænat
- Rule #2 applies: kænt
- Rule #3 applies: kãënt
- Rule #4 applies: kænʔ
- Rule #5 applies: kæʔ

Surface form: [kæʔ]

(2) **Constraint-based schema**

Underlying representation: /kænnat/

↓ possible forms

↓ Surface form: [kæʔ] selected by constraints

In contrast to a serial rule-based approach, the constraints relevant to the form are all considered in parallel, simultaneously. What determines the outcome is not the serial ordering of rules, but the relative strengths, or **rankings**, of the constraints. A constraint is not absolute, but can be violated when a higher-ranked constraint applies to the same form.

For example, take the word “impossible”, assuming an underlying form of /in-possible/ (the nasal assimilates in place to the following /p/). Suppose there is one constraint that says “preserve the underlying place of a consonant”, and another constraint that says “nasals have the same place features as a following consonant”. So there are two possible outcomes. If the “preserve place” constraint is more highly ranked, there will be no assimilation, and we get “impossible.” But if the “nasal has same place” constraint is more highly ranked, there will be assimilation, and we get “impossible”.

Since real examples usually are more complex than this, rankings are usually displayed in a **tableau** (plural either **tableaux** or **tableaus**, depending on how erudite one wishes to sound). A tableau shows possible surface forms, the constraints relevant to those forms, and how the constraints are violated. Let us consider the concrete example of devoicing of the English plural morpheme /-z/ after a voiceless stop. We will refer to three constraints, which are named and defined below. Note that underlying and surface forms are generally termed **input** and **output**.

(3) **Sample Constraints**

- **CC(voice):** consonant clusters must have identical values of the [voice] feature
- **IDENT(voice):** the value of [voice] in an input segment is identical to its value in the output
- **IDENT(voice)ROOT:** the value of [voice] in an input root segment is identical to its value in the output

---

*Though the notions of underlying representation and surface form are still used by most, some researchers (e.g. Russell 1995, Flemming 1995, Hammond 1995, Burzio 1996) have proposed that OT makes the idea of underlying representations superfluous.*
Names of constraints are mnemonics for the full definition of the constraint, and are usually short to fit concisely into a tableau. In tableaus, constraints are listed in the top row; higher-ranking constraints are to the left, lower ones to the right. A solid line between the columns means the constraints are definitely ranked in that order, while a dotted line indicates that the ranking between those candidates is undetermined. The notation “>>” means “outranks.” In the tableau below, I assume the underlying representation of [buks] ‘books’ is /buks+z/; this is listed in the top left cell below.

(4) [buks] ‘books’, with $\text{CC(voice)}, \text{IDENT(voice)}_{\text{ROOT}}$ $>>$ $\text{IDENT(voice)}$

<table>
<thead>
<tr>
<th></th>
<th>CC(voice)</th>
<th>IDENT(voice)$_{\text{ROOT}}$</th>
<th>IDENT(voice)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. buks</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. bugz</td>
<td></td>
<td>![1] *</td>
<td></td>
</tr>
<tr>
<td>c. bukz</td>
<td>![1] *</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the left column, under the underlying representation /buks+z/, are several candidates generated from the underlying representation. The “winning candidate,” the one which is actually pronounced, is denoted by a pointing finger («) or some other marker. The order in which these candidates are listed is not important, though the winning candidate is often listed first. The number of generated candidates is considered to be infinite, but only the most likely and relevant ones are actually listed in the tableau. These candidates are judged as to how well they conform to the set of constraints. The constraints we are considering here are in the top row. If a candidate violates a constraint, that violation is marked with an asterisk (*). A particular candidate can violate one or more constraints. The violation that actually prevents that candidate from surfacing is called a “fatal violation” and is indicated by an exclamation point to the right of the asterisk that marks that violation (*!). Often the cells to the right of this fatal violation are shaded as a visual aid to draw attention to it, and to show that the constraints in those columns are irrelevant to evaluating that candidate.

So in the tableau above, candidate (a) is the winning candidate, even though it has violated the constraint $\text{IDENT(voice)}$. It violates it because the suffixal [s] in the output is unvoiced, while the input /z/ is voiced. Candidate (b) also violates $\text{IDENT(voice)}$, but more importantly, also violates $\text{IDENT(voice)}_{\text{ROOT}}$. It is more important to preserve voicing in a root consonant than in other consonants, so $\text{IDENT(voice)}_{\text{ROOT}}$ outranks $\text{IDENT(voice)}$. A violation of $\text{IDENT(voice)}_{\text{ROOT}}$ is enough to make candidate (b) lose. Candidate (c) loses because it violates $\text{CC(voice)}$. From the data above, we cannot tell the respective ranking of $\text{CC(voice)}$ and $\text{IDENT(voice)}_{\text{ROOT}}$, so they are separated by a dotted line.

Only the candidates most relevant to the phenomenon under consideration are listed, in this case voicing of the final consonant. Other candidates which could be considered include ones in which several vowels are inserted, or all consonants are deleted,

---

A considerable literature is growing on “positional” contrast, formalizing the observation that initial vs. final position in a word or whether the sound occurs in root or affix, makes a difference in what contrasts are available in a language, how faithful the output is to the input, and how likely neutralization is to occur. See Beckman (1997) and Casali (1997), as well as Steriade (1994, 1997).
or the entire output is [aaaaaaargh]. These are quite different from the input and would not normally be considered. More formally, they would be eliminated from consideration by other constraints not listed here. For example, [bok] would be eliminated by a constraint which prohibits deletion of consonants (\textbf{MAX(C)}, in the listing below).

Constraints in Optimality Theory are proposed to be universal, that is, all constraints are present in all languages. The differences in phonologies of various languages are due to the difference in rankings of constraints. This re-rankings of constraints across languages can provide a fruitful field of cross-linguistic inquiry. The \textbf{typology} which is produced by different rankings of constraints will predict specific patterns across languages depending on the ranking of the constraints under examination, and is one check on whether the constraints proposed have any connection with reality. If, for example, three independently-rankable constraints A, B and C are proposed, then there are six possible rankings, assuming it is possible to clearly determine the ranking of each with respect to the others. If these constraints are all actually valid ones, then languages could be found which exhibit each of the six rankings. The search for all these languages is quite time-consuming, of course, which is quite likely the reason so few wide-ranging cross-linguistic studies have actually been carried out.\footnote{One cross-linguistic study in the OT framework is Casali (1997), who surveys 87 languages examining vowel elision phenomena. Another ongoing attempt at a wide sampling of languages is Cahill (1998), who to date has examined 28 languages which have floating tonal associative morphemes.}

To sum up, Optimality Theory is a “non-derivational” approach to phonology; it does not have a series of steps or levels from underlying representation to surface form. The following table summarizes the differences between OT and rule-based approaches.

\begin{tabular}{|l|l|}
\hline
\textbf{Rule-based approach} & \textbf{Optimality Theory} \\
\hline
derivational & non-derivational \\
serial & parallel \\
rules & constraints only \\
language-specific rules and constraints & universal constraints \\
intermediate levels & only underlying and surface forms \\
\hline
\end{tabular}

\textbf{2. What OT can do}

OT excels in unifying accounts of varied phenomena which could not be unified under a rule-based system. What have been termed “conspiracies” of rules have been noted since Kisseberth (1970). Conspiracies are several rules that work together to give the same result in a single language. In OT, a single set of constraints can account for varied inputs having similar outputs.

But this unifying strategy may also be extended to cross-linguistic situations. A concrete example is rules of insertion and deletion. Let us consider two hypothetical languages. Given a root ending in a consonant and a suffix beginning with a consonant,
Language A inserts a vowel between the root and the suffix, while Language B deletes the final stem consonant:

(6) Language A  /bak + to/  →  [bakɨto]
Language B  /bak + to/  →  [bato]

What unites these, the driving force in both cases, is the push for a CV syllable pattern and avoidance of a closed, CVC syllable. There is a constraint called **NOCODA**, prohibiting closed syllables, which outranks any other relevant constraint, i.e. it is **undominated**. The two languages satisfy **NOCODA** in two different ways, using the same constraints, but with different rankings. The relevant constraints are listed below.

(7) **NOCODA**: codas are not allowed
**MAX(C)**: any consonant in the input is present in the output
(prohibits deletion of consonants)
**DEP(V)**: any vowel in the output is present in the input
(prohibits insertion of vowels)

These are commonly invoked constraints. **MAX** is for “maximize the output”, and **DEP** is for the output “depends on the input”.⁶ Below are the tableaus for hypothetical language A and Language B. Neither language allows codas, so **NOCODA** is undominated. The difference is in the rankings of the other two constraints. In Language A, **MAX(C)** outranks **DEP(V)**, and so deleting a consonant is worse than inserting a vowel. So to satisfy **NOCODA** and **MAX(C)**, a vowel is inserted. We will assume the inserted vowel here is [i]; the issue of choosing between this and other possible vowels is ignored here for the sake of brevity.

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⁶ In the original Optimality Theory of Prince and Smolensky (1993), there were **PARSE** and **FILL** constraints which related to insertions and deletions. These have been replaced in the more recent Correspondence Theory version of Optimality Theory in McCarthy & Prince (1995), which uses the “Faithfulness” constraints **IDENT**, **MAX**, and **DEP**. These latter are the ones I discuss here.
(8) Language A - insertion of vowel into CC cluster

<table>
<thead>
<tr>
<th>/bak + to/</th>
<th>NOCODA</th>
<th>MAX(C)</th>
<th>DEP(V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. bakito</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. bato</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c. bakto</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On the other hand, in Language B, DEP(V) outranks MAX(C), so it is worse to insert a vowel than to delete a consonant. To satisfy the top-ranked NOCODA and DEP(V), a consonant is deleted. (Deciding which consonant is deleted would involve another constraint or constraints.)

(9) Language B - deletion of consonant in CC cluster

<table>
<thead>
<tr>
<th>/bak + to/</th>
<th>NOCODA</th>
<th>DEP(V)</th>
<th>MAX(C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. bato</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. bakito</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c. bakto</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A derivational generative account of the same phenomena involves rules, of course. In Language A, we need a rule inserting [i] between two consonants, and in Language B, we need a rule deleting the first of two consonants:

(10) a. Rules:

Language A: **i-insertion rule**\( \emptyset \to i / C \_C \)

Language B: **C-deletion rule:**\( C \to \emptyset / \_C \)

b. Derivations:

Language A

underlying form /bakto/

i-insertion rule bakito

surface form [bakito]

Language B

underlying form /bakto/

C-deletion rule bato

surface form [bato]

These rules appear simpler than the machinery needed for the optimality approach. If a single process of a single language is considered, it truly is more compact to express that process with a rule. However, there are other factors to consider. First, a constraint in OT does not apply only to the situation at hand, but will make its presence felt in many different phonological contexts. When one considers the total number of rules needed to account for the phonology of a language vs. the total number of constraints which are active in a language, they might appear more equal (actually, this is an exercise that has
never been attempted to my knowledge). Second, and perhaps more importantly, the same constraints can be used cross-linguistically, with the only difference being a difference in ranking. One can see a functional unity to vowel insertion vs. consonant deletion illustrated in the hypothetical but realistic Languages A and B when constraints are used, but with the rules, there is no formal relationship at all between the two processes.

Constraints can be of many forms, but fall into two major types. One type is the so-called “faithfulness” constraints, and the other type is constraints to enforce well-formedness. The faithfulness constraints have been referred to already; they enforce fidelity of the output to the input. In perfect faithfulness, the output is identical to the input. The Max family of constraints prohibits deletion of segments and so “maximizes” the output. The Dep family of constraints prohibits insertion of segments and so the output “depends” on the input. The Ident family of constraints says that a given feature has the same value in the output as in the input. Generally, then, Max and Dep constraints refer to the presence or absence of segments, and Ident constraints to values of individual features.7 The general form of the constraints is the following.

\[
(11) \textbf{Ident}(F): \text{a feature has the same value in the input as in the output.} \\
\textbf{Max}(S): \text{a segment present in the input is also present in the output} \\
\textbf{Dep}(S): \text{a segment present in the output is also present in the input}
\]

Above, (F) can be any feature, and (S) can be any segment.8

The other major constraint type is constraints that enforce well-formedness. Certain sequences are prohibited (e.g. our *CC earlier), adjacent segments must agree in certain qualities (like our CC(voice) earlier), etc. A major schema of well-formedness constraints is the Align strategy, in which one entity “aligns”, or has coinciding edges, with another entity. As an example using features, one may observe that if a suffix has a round vowel, all the root vowels are also round. A constraint expressing this generalization is

\[
(12) \textbf{Align}([+rd], \text{Left}; \text{Wd, Left}): \text{the left edge of a [+round] feature is aligned with the left edge of a word}
\]

In a rule-based framework, we would say the [+round] has spread leftward. In OT, we observe that all the vowels to the left are round. One characteristic of Align constraints is that they can be gradiently violated. That is, if the element under consideration is perfectly aligned, there is no violation. But if it misses by one segment, the constraint is violated once, if it misses by two segments, there are two violations of the constraint, and so on.

7 With the view of some features as privative rather than binary (e.g. [voice] is either present or absent, not having a value of [+] or [-]), sometimes the Max and Dep constraints are applied to individual features as well, such as [voice] (Lombardi 1998) and tones (Myers & Carleton 1996).
8 A fuller name of these constraints includes “I-O”, for “Input-Output”, since it is the correspondence between input and output forms that is being discussed, e.g. Max-I0(V), referring to a vowel in the input and output. Other correspondences discussed in the literature are B-R (base-reduplicant) and I-R (input-reduplicant). For most relationships, however, it is the relationship between input and output which is in focus, and often, as in this paper, the I-O is omitted.
Let us give a concrete illustration. Bantu languages often have elaborate schemes for spreading tones. A High tone from a prefix may make an entire word High-toned. But in many Bantu languages, the final vowel is never High, though the rest of the word might be. In a rule-based approach, we might have a rule that spreads a High tone rightward as far as it can, then another rule that delinks the High on a final syllable. In OT, this translates into two constraints. One constraint says that a High tone is aligned to the right edge of a word, and another constraint prohibits High tones on word-final syllables (or moras, if that is the tone-bearing unit).

(13) \textbf{*Final-H: a High tone is not allowed on a word-final syllable}

\textit{ALIGN(High, Rt: Wd, Rt): the right edge of a High tone is aligned with the right edge of a word (ALIGN H-Rt)}

Let us take a hypothetical example \textit{kí-bábábà} (acute accents indicate High tone, grave accent is Low tone), where \textit{kí-} is a High-toned prefix, and \textit{bababa} in a context without the prefix is all Low-toned, so we know the High tones in it are a result of the prefix. Using the two constraints above, we have the following tableau.

(14) Hypothetical \textit{kí-bábábà}

<table>
<thead>
<tr>
<th>ki-bababa</th>
<th>*Final-H</th>
<th>ALIGN H-Rt</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ki-bábábà</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b. ki-bábábà</td>
<td>!</td>
<td>**</td>
</tr>
<tr>
<td>c. ki-bábábà</td>
<td></td>
<td>**!</td>
</tr>
<tr>
<td>d. ki-bábábà</td>
<td></td>
<td>*<em>!</em></td>
</tr>
</tbody>
</table>

The winning candidate (a) violates \textit{ALIGN H-Rt}, since the High tone is not aligned with the right edge of the word. But aligning the High with the right edge, as in candidate (b), violates the more highly-ranked \textit{*Final-H}, and loses for that reason. Candidates (c-d) do not violate \textit{*Final-H}, but lose because they violate \textit{ALIGN H-Rt} more times than (a) does. Candidate (c) has a High tone two syllables from the edge of the word, and so incurs two violations of \textit{ALIGN H-Rt}, and candidate (d) incurs three violations. Since two violations are enough to make it lose (compared to (a)), the fatal violation (!) is marked after the second asterisk in both (c) and (d).

3. A more in-depth example

A feeding order of rules is easily handled by Optimality Theory. For example, let us take an input of /spap/ in Language A. The surface form is [šipap], reflecting insertion of the vowel [i] and palatalization of the /s/ to [š]. In a rule-based account, we have a rule of i-insertion and a rule of palatalization. The rule of i-insertion feeds palatalization; palatalization does not occur except before [i]. So a derivation of [šipap] would be:
If the order of the rules were reversed, we would get the different output [sipap], so the ordering is crucial.

In an Optimality Theory approach, there are several possible approaches we could take, and which we choose depends on the patterns of the language as a whole. Here is one approach. The vowel insertion is presumably motivated by a desire to avoid word-initial consonant clusters. To account for this, we might note that there are no consonant clusters anywhere in the language, and so a constraint *CC, forbidding consonant clusters altogether, would be the relevant one. The Max(C) and Dep(V) constraints from (7) will be called upon again, with Max(C) outranking Dep(V) as in (8) to get insertion of a vowel rather than deletion of a consonant. To force palatalization, we might propose either one constraint forcing sharing of a [-anterior] feature of [coronal] segments, or a combination of constraints which give that effect. I will assume here a single constraint Pal. The tableau would then be:

(16) Palatalization and insertion of i

<table>
<thead>
<tr>
<th>/spap/</th>
<th>Pal</th>
<th>*CC</th>
<th>Max(C)</th>
<th>Dep(V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ŝipap</td>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. sipap</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. spap</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. sap</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

As before, motivating the insertion of [i] rather than another vowel would require more constraints than what are listed, and we will ignore this for our purposes here. We can see that we can easily get the correct output with appropriate constraints. Candidate (a), the winning candidate, violates Dep(V) by inserting the vowel, but since that constraint is ranked low, that is permissible. Candidate (b) loses by not palatalizing [s] before the [i]. Candidate (c) loses by having a consonant cluster. Candidate (d) loses by deleting a consonant. From the above tableau, we can see that Pal, *CC, and Max(C) are all ranked above Dep(V), since a violation of Dep(V) is not fatal, but a violation of the other constraints is. However, we cannot determine the relative rankings of these other constraints without looking at more data.

4. Further issues

Three other topics relating to OT deserve comment: the assumed universality of constraints, what criteria are used to evaluate a constraint as a principled or “good” one, and how well OT handles cases of relations between rules.

Constraints are generally assumed to be universal, that is, all constraints exist in all languages, though they may be ranked so low that their effects are not visible. (Prince & Smolensky 1993, McCarthy & Prince 1995, Archangeli 1997). However, Russell (1997),
in the same volume as Archangeli, maintains that constraints which refer to categories specific to a particular language cannot be part of Universal Grammar, and presents several such cases. This seems an irrefutable point, since a morpheme of a particular language cannot possibly be universal. In my own dissertation (Cahill in progress), there are several examples of constraints which must refer to specific Konni morphemes.

The matter of what makes a constraint “good” or “principled” is still an open question. Most researchers do not explicitly discuss the issue, but some have. Recent work by several researchers (e.g. Beckman 1997, Casali 1997, Steriade 1994, 1997, Jun 1995, Kaun 1995, Flemming 1995, Kirchner 1998, Boersma 1998) suggests functional reasons for many constraints based on phonetics. Hayes (1996), while acknowledging the phonetic basis for many constraints, has pointed out the difficulty of translating experimental phonetic results, which typically give gradient results, into phonological terms which are typically categorial. He suggests two types of “principled” constraints: those based on typological, cross-linguistic evidence, and those motivated by phonetic functionalism. As a rule of thumb, I believe it is good practice to motivate the constraints one uses by either referring to their cross-linguistic commonality or their inherent phonetic plausibility.

There has been considerable effort expended on the intricacies and motivations for rule ordering. How does this type of data fare in an OT approach? Briefly, the answer is both very well and not very well at all, depending on the type of rule interaction considered. For cases involving feeding orders, for example, OT performs well, as in the last section, but cases where counterfeeding rule order is involved have been problematic.9

5. Resources for Optimality Theory

The most basic introduction to Optimality Theory is by Archangeli and Langendoen (1997). This is quite readable and includes chapters on how OT applies to feature theory, morphology, and even syntax, as well as phonology. The foundational works by Prince & Smolensky (1993), McCarthy & Prince (1993a, b), McCarthy and Prince (1995) are more difficult reading, but worthwhile. Much of the work in OT has been published electronically instead of in paper form. The biggest repository of such electronic OT papers is the Rutgers Optimality Archive Internet website, found at http://ruccs.rutgers.edu/roa.html. Each paper on this site has been given its own unique reference number. In this article, when a reference has been taken directly from the Rutgers Optimality Archive, the source is given as ROA-###.

References

9 An additional topic is how OT relates to other theories of phonology. The main answer is that it does not address these theories directly. One may have autosegmental representations in OT tableaus, with constraints ruling out one configuration of association lines vs. another. Feature geometry can be included in OT (though there have been claims that OT makes association lines and Feature Geometry superfluous). Metrical grids can likewise be incorporated into OT. Lexical phonology with its ordered strata might be thought of as generally antagonistic to the spirit of OT, but even McCarthy & Prince (1993a:24) propose strata, each having its own distinct constraint ranking, for Axininca Campa.


Boersma, Paul. Functional Phonology: Formalizing the interactions between articulatory and perceptual drives. Ph.D. dissertation, University of Amsterdam. [several chapters available on ROA].


Hammond, Mike. 1995. There is no lexicon! ROA-43-0195.


McCarthy, John, and Alan Prince. 1993a Prosodic Morphology I. RuCCS TR-3, Rutgers University.


Steriade, Donca. 1994. Positional Neutralization and the Expression of Contrast. ms, UCLA
Steriade, Donca. 1997. Licensing Laryngeal Features. ms, UCLA.
**Chamicuro morphophonemic data**

possessed nouns (the genitive construction)

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<th>his/her___</th>
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<td>pekáno</td>
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<td>pnahmüdle?te</td>
<td>ipnahmüdle?te</td>
<td>pnahmüdle</td>
<td>swamp, marsh</td>
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<td>pollawatíne</td>
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<td>itópi</td>
<td>tópi</td>
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</tr>
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<td>to?sóna</td>
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učičíňe  čičíňe  ičičíňe  čiči  chili pepper
učáňo  čáňo  ičáňo  čáňo  neck
učoʔkapéle  čoʔkapéle  ičoʔkapéle  čoʔkapélí  fishhook
usakódlía  sakódlía  isakódlía  sakódlía  saliva
usaʔpúne  saʔpúne  isaʔpúne  sáʔpu  lake
ušáki  šáki  išáki  šáki  vagina
ušíxpa  šíxpa  išíxpa  šíxpa  hand
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ušʔénu  šénu  išʔénu  šénu  hair
ušalʔotáʔte  šálʔotáʔte  išalʔotáʔte  šálʔóta  macaw (bird)
umamodiłáne  mamodiłáne  imamodiłáne  mamódła  salt
umediłőte  međiłőte  imeđiłőte  međiłőti  knee
uménu  ménú  imeńu  ménú  tongue
umodiłotáʔte  modiłotáʔte  imodiłotáʔte  modiłóta  woman, female
ulokoteʔʃóʔlo  lokoteʔʃóʔlo  ilokoteʔʃóʔlo  lokoteʔʃóʔlo  blowgun
waçôdle  paçôdle  yaçôdle  ačôdle  guts, intestines
wahkedîlóhki  pahkedîlóhki  yahkedîlóhki  ahkedîlóhki  heart
wahtíníne  pahtíníne  yahtíníne  ahtíni  path, trail
waškôdlólí  paškôdlólí  yaškôdlólí  aškôdlólí  arrow
wašmudleʔkódłó  pašmudleʔkódłó  yašmudleʔkódłó  ašmudleʔkódłó  wooden club
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waʔmusnáhte  paʔmusnáhte  yaʔmusnáhte  aʔmusnáhte  lung
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akúhtu  kuhtúsi  ikuhtukána  kuhtúči  foot, paw
at’ekođlíone  t’ekođlonési  it’ekođlonekána  baby’s rattle
at’emo?yéné  t’emo?yenési  it’emo?yenekána  stick
acaskódlíone  časkódlonési  ičaskódlonekána  vulture, buzzard
acéna?tóne  čena?tonési  ičena?tonekána  tree
ačépodíalihsáne  čepodíalihsanési  ičepodíalihsanekána  fermented manioc
ačičíne  čičinési  ičičinekána  chili pepper
acáno  čanósi  ičanokána  čanóči  neck
acho?kapéle  čo?kapelési  ičo?kapelekána  fishhook
asakóđla  sakódlási  isakódlakána  saliva
asa?púne  sa?punési  isa?punekána  lake
ašáki  šakísi  išakikána  vagina
ašíxpa  šíxpási  išíxpakána  šíxpáči  hand
ašiliška?tépi  šiliška?tepísí  išiliška?tepikána  bow (for arrows)
ašútoki?te  šútoki?tési  išútoki?tekána  drum
aš’énú  š’enuísi  iš’enuukána  š’enuči  hair
ašal’otá?te  šal’ota?tési  išal’ota?tekána  macaw (bird)
amamodílane  mamodílanési  išamamodílanekána  salt
amedílo?te  medílo?tési  imeďílo?tekána  knee
aménu  menúsi  imenukána  tongue
amodílotá?te  modílotá?tési  imodílotá?tekána  woman, female
awačódle  pačodlési  yačodlekána  guts, intestines
awahkedílóghi  pahkedílohkési  yahkedílohkikána  heart
<table>
<thead>
<tr>
<th>English</th>
<th>Yankton Lakota</th>
<th>Gloss</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>path, trail</td>
<td>pahtininési</td>
<td>yaht ininekána</td>
<td>aškodlíči</td>
</tr>
<tr>
<td>wooden club</td>
<td>paškodlísi</td>
<td>yaškodlíikána</td>
<td>ašmudliči</td>
</tr>
<tr>
<td>mouth</td>
<td>pawanási</td>
<td>yawanakána</td>
<td>awanáči</td>
</tr>
<tr>
<td>lung</td>
<td>pašmudlísi</td>
<td>yašmudlíikána</td>
<td>ašmučiči</td>
</tr>
<tr>
<td>shoulder</td>
<td>pašmudlí</td>
<td>yašmudlíikána</td>
<td>ašmučiči</td>
</tr>
<tr>
<td>lemon</td>
<td>penopínési</td>
<td>yenopinekána</td>
<td>ašmudlíči</td>
</tr>
<tr>
<td>blood, resin</td>
<td>pi:lási</td>
<td>yi:lakána</td>
<td>i:láči</td>
</tr>
<tr>
<td>liver</td>
<td>pošlonési</td>
<td>yošlongékána</td>
<td>ohpanáči</td>
</tr>
<tr>
<td>collared peccary</td>
<td>puhsí</td>
<td>yuhsikána</td>
<td>uhšíči</td>
</tr>
<tr>
<td>fat</td>
<td>punixsalési</td>
<td>yuniśsalékána</td>
<td>water</td>
</tr>
<tr>
<td>sleeping mat</td>
<td>pustawalési</td>
<td>yustawalekána</td>
<td>ustawaliči</td>
</tr>
</tbody>
</table>

Present tense verbs, singular subjects

<table>
<thead>
<tr>
<th>First person singular</th>
<th>Second person singular</th>
<th>Third person singular</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>upahkawá?ti</td>
<td>pahkawá?ti</td>
<td>ipahkawá?ti</td>
<td>sow, plant</td>
</tr>
<tr>
<td>upahyítúni</td>
<td>pahyítúni</td>
<td>ipahyítúni</td>
<td>practice, learn</td>
</tr>
<tr>
<td>upakařásti</td>
<td>pakařásti</td>
<td>ipakařásti</td>
<td>pay</td>
</tr>
<tr>
<td>upakati?tále</td>
<td>pakati?tíále</td>
<td>ipakati?tále</td>
<td>follow him/her/it</td>
</tr>
<tr>
<td>upamošóški</td>
<td>pamošóški</td>
<td>ipamošóški</td>
<td>push</td>
</tr>
<tr>
<td>upayakswe?ti</td>
<td>payakswe?ti</td>
<td>ipayakswe?ti</td>
<td>hunt</td>
</tr>
<tr>
<td>upa?lísne</td>
<td>pala?lísne</td>
<td>ipa?lísne</td>
<td>send, order, command (tr)</td>
</tr>
</tbody>
</table>
upaʔpésne  paʔpésté  ipaʔpésne  finish, end (tr)
upaʔwawákne  paʔwawákte  ipaʔwawákne  dry (tr)
upeskiʔtále  peskiʔtále  ipeskiʔtále  prepare it, arrange it
upohšamáʔti  pohšamáʔti  ipohšamáʔti  change (clothes)
upulíkne  pulíkne  ipulíkne  begin, start (tr)
utaʔtádle  tłaʔtádle  itaʔtádle  serve him/her/it
utilíšne  tlíšte  itilíšne  wipe, clean (tr)
utóhki  tóhki  itóhki  count
utošóhki  tošóhki  itošóhki  enter, go in
utoʔmastále  toʔmastále  itoʔmastále  finish it, end it
ukamáni  kamáni  ikamáni  wash, bathe (oneself)
ukasósti  kasósti  ikasósti  obey, listen, pay attention
ukéʔmi  kέʔmi  ikέʔmi  hear
ukíhki  kíhki  ikíhki  arrive
ukiłkačáʔti  kilkačáʔti  ikilkačáʔti  spin (thread)
ukíti  kíti  ikíti  dig
ukoʔčomáʔti  koʔčomáʔti  ikoʔčomáʔti  sit down
ut’uʔmási  t’uʔmási  it’uʔmási  kiss
učelt’akamáʔti  čelt’akamáʔti  ičelt’akamáʔti  shout
usenústi  senústi  isenústi  sweat
usepyóʔti  sepyóʔti  isepyóʔti  fight
ušišísti  šišísti  išišísti  whistle
ušišólti  šišólti  išišólti  pull
ušitaláʔti  šitaláʔti  išitaláʔti  break
ušit’opásne  šit’opáste  išit’opásne  pull out, pull up by the roots (tr)
uš'elé?ti
ušakatulú?ti
ušamú:ti
ušanata?čomawáni
ušana?tále
ušapési
ušapúki
ušá?ki
ušá?ti
umahkó?ti
umaš'entá?ti
umaš'entá?tále
unačá?ti
unísi
ulá:ti
ulákne
uláški
wačíkne
wačíkne
wačíkne
waškalá?ti
waštími
wašpéhki

Š'elé?ti
Šakatulú?ti
Šamú:ti
Šanata?čomawáni
Šana?tále
Šapési
Šapúki
Šá?ki
Šá?ti
Mahkó?ti
Maš'entá?ti
Maš'entá?tále
Načá?ti
Nísi
Lá:ti
Lákne
Láški
Pačíkne
Pačíkne
Pačíkne
Paškalá?ti
Paštími
Pašpéhki

iš'elé?ti
išakatulú?ti
išamú:ti
išanata?čomawáni
išana?tále
išapési
išapúki
išá?ki
išá?ti
imahkó?ti
imaš'entá?ti
imaš'entá?tále
ináčá?ti
Inísi
Ilá:ti
Ilákne
Iláški
Yačíkne
Yačíkne
Yačíkne
Yapasá?ti
Yapasíki
Yapaškalá?ti
Yaštími
Yašpéhki

Die
Play
Fear, be afraid
Work
Do it, make it
Look for, seek
Cook
Dance
Paint
Rob, steal
Help, protect
Help him/her/it, protect him/her/it
Speak
See
Laugh
Take out, remove (tr)
Throw away
Hold, have, grab (tr)
Fall (down)
Smoke tobacco
Swim
Fly
Kill
Stand (up)
Hit, beat
watepastále  
patépastále  
yatepastále  
can, be able (to)

watošamáhti  
patošamáhti  
yatošamáhti  
wash (clothing)

waʔmúhti  
paʔmúhti  
yaʔmúhti  
smell

waʔʃóʔti  
paʔʃóʔti  
yaʔʃóʔti  
put in

wáʔti  
páʔti  
yáʔti  
go up

waʔyíhki  
paʔyíhki  
yaʔyíhki  
get up, arise

weːpáʔti  
peːpáʔti  
yeːpáʔti  
answer, respond

wepíki  
pépíki  
yépíki  
return, come back

wéʔči  
péʔči  
yéʔči  
ask for

woʔkále  
póʔkále  
yóʔkále  
put it

woʔkočíʔti  
póʔkočíʔti  
yóʔkočíʔti  
hide

wóʔti  
póʔti  
yóʔti  
give

wuhséʔti  
puhseʔti  
yuhséʔti  
move

wumakíhti  
pumakíhti  
yumakíhti  
dream

wusmatehpáški  
pusmatehpáški  
yusmatehpáški  
jump

wúsmi  
púsmi  
yúsmsi  
sing

wusmúski  
pusmúski  
yusmúski  
run

Present tense verbs, plural subjects

we__  
you (pl)__  
they__  
gloss

apahkwáʔti  
pahkawaʔtísi  
ipahkawaʔkána  
sow, plant

apahyitúni  
pahyitunísi  
ipahyituŋkána  
practice, learn

apakařásti  
pakařástísi  
ipakařaskána  
pay

apakatiʔtále  
pakatiʔtalési  
ipakatiʔtalekána  
follow him/her/it
ašišíti
ašišóti
ašitalá?ti
ašit’opásne
aš’élé?ti
ašakatukulú?ti
ašamú?ti
ašanata?čomawání
ašana?tále
ašapési
ašapúki
ašá?ki
ašá?ti
amahkó?ti
amaš’enta?ti
amaš’enta?tále
anačá?ti
anísí
alá:ti
alákne
aláški
awačíkne
awadlíki
awahtopohkašíhti
awasá?ti
šišistísi
šišořtísi
šitala?tísi
šit’opastési
š’ele?tísi
šakatuku?tísi
šamu:tísi
šanata?čomawanísi
šana?talési
šapesísi
šapukísí
ša?kísí
ša?tísi
mahko?tísi
maš’enta?tísi
maš’enta?talési
nača?tísi
nisísi
la:tísi
laknési
laškísí
pačíknsí
paďlíkísí
pahtopohkašíhtísi
pasa?tísi
išišiskána
išišolkána
išitala?kána
išit’opasnekána
iš’elekána
išakatuku?kána
išamu:kána
išanata?čomawanjkána
išana?talekána
išapeskána
išapukkána
išakkána
iša?kána
imahko?kána
imaš’enta?kána
imaš’enta?talekána
inača?kána
iniskána
ila:kána
awasá
ti
pasa?tísi
whistle
pull
break
pull out, pull up by the roots (tr)
die
play
fear, be afraid
work
do it, make it
look for, seek
cook
dance
paint
rob, steal
help, protect
help him/her/it, protect him/her/it
speak
see
laugh
take out, remove (tr)
throw away
hold, have, grab (tr)
fall (down)
smoke tobacco
swim
awasíski  pasiskísi  yasiskána  fly
awaškalá?ti  paškala?tísi  yaškala?kána  kill
awaštími  paštimísí  yaštimkána  stand (up)
awašpéhki  pašpehkísi  yašpehkána  hit, beat
awatepastále  patepastalésí  yatepastalekána  can, be able (to)
awatošamáhti  patošamahtísí  yatošamahkána  wash (clothing)
awa?múhti  pa?muhtísi  ya?muhkána  smell
awá?ti  pa?tísi  ya?kána  go up
awa?yíhki  pa?yihkísi  ya?yihkána  get up, arise
awepíki  pepikísi  yepikkána  return, come back
aweʔči  peʔčísi  yečkána  ask for
awoʔkále  poʔkalésí  yoʔkalekána  put it
awoʔkočʔti  poʔkočʔtísi  yoʔkočʔkána  hide
awóʔti  poʔtísi  yoʔkána  give
awuhseʔti  puhseʔtísi  yuhseʔkána  move
awumakíhti  pumakihtísí  yumakihkána  dream
awusmatehpaški  pusmatehpaškísi  yusmatehpaškána  jump
awúsmi  pusmísí  yusmkána  sing
awusmúski  pusmuskísi  yusmuskána  run
***Important note: here are a few more pieces of data that you should keep in mind as you are doing your analysis. Chamicuro has nouns and adjectives such as the following:

- [pčahtóki] wild, fierce (animal)
- [pčoyi] poop, stern (of a canoe)
- [pkwáči] cultivated field
- [pláwa] long
- [pnahmúđle] swamp, marsh
- [pnáwa] deep, profound
- [pšáwa] bitter
- [pwáwa] heavy
- [pwáye] feather, body hair
- [pwáʔto] sapodilla or marmalade tree
- [pwenáli] great mullein plant
- [pyaʔčóma] handsome, beautiful (m)
- [pyaʔkihnáni] happy, glad, content
- [pyáʔpa] beautiful, pretty (f)
- [pyaʔsíno] smooth, flat

sources of data:

Parker, Steve. 2010. “Chamicuro data: morphophonemic paradigms (Datos del chamicuro: paradigmas morfofonépicos).” SIL Language and Culture Documentation and Description 11.
Instructions for Chamicuro morphophonemics problem (part 1)

Background

In the set of Chamicuro phonetic data which appear on separate pages in this course packet, I use the Americanist transcription system since this is how most of the work on Chamicuro phonology has been published. The descriptions of some of the more unusual segments are below, plus a few standard IPA equivalencies:

[a] = [a] = low, central, unrounded vowel
[ʃ] = [ʃ] = voiceless alveopalatal fricative
[ʃ] = voiceless retroflexed alveopalatal fricative
[ʃ] = voiceless laminal alveolar fricative, an allophone of /ʃ/ before the vowel /i/
[ʃ] = voiceless palatalized laminal alveolar fricative, an allophone of /ʃ/ before the vowel /e/
[tɾ] = [tʃ] = voiceless alveolar affricate
[ɛ] = [ɨ] = voiceless alveopalatal affricate
[ɛ] = [ɨʃ] = voiceless retroflexed alveopalatal affricate
[h] = voiceless alveolar lateral fricative, a syllable-final allophone of /l/
[dɾ] = voiced alveolar lateral affricate, an optional allophone of /l/ between vowels
[l'] = [l] = voiced (alveo)palatal lateral (approximant)
[n] = voiced alveopalatal nasal
[y] = [j] = voiced palatal glide or approximant
[r] = [ɾ] = voiced alveolar tap or flap (in loanwords)
[i] = [i] = high, front, lax, unrounded vowel, an allophone of /i/ in certain closed syllables
[χ] = [ç] = voiceless palatal fricative, an optional allophone of /h/ following the vowel /i/
[w] = [w] = voiceless labial-velar glide (approximant), a syllable-final allophone of /w/ and /h/
[y] = [y] = voiceless palatal glide (approximant), a syllable-final allophone of /y/
(i) = an abstract underlying vowel posited for phonological reasons, which is deleted in surface forms
[aʔ] = an optional, non-phonemic, non-syllabic echo vowel (svarabhakti)
[ɛ] = a nasalized vowel
[V:] = [Vː] = contrastively lengthened (bimoraic) vowels
[ˈV] = vowels bearing primary stress
[ˈV] = vowels bearing secondary stress
~ = free variation
For this exercise, you do NOT need to worry about analyzing any allophonic (subphonemic) phenomena. That is, do NOT account for vowel laxing; syllable-final and intervocalic allophones of the lateral /l/; allophones of /ʃ/ before front vowels and consonants; stress assignment; etc., or any other details which are clearly not morphophonemic in nature. If in doubt, ask me!

Glosses

To illustrate what all of these forms typically mean, according to the labels at the top of the columns, I spell out the first noun and the first verb below:

[pekáno] ‘flesh, meat’
[upekáno] ‘my flesh, my meat’
[pekáno] ‘your (singular) flesh, your (singular) meat’
[ipekáno] ‘his/her flesh, his/her meat’
[apekáno] ‘our flesh, our meat’
[pekanósi] ‘your (plural) flesh, your (plural) meat’
[ipekanokána] ‘their flesh, their meat’
[pekanóči] ‘anybody’s flesh, anybody’s meat’

[upahkawáʔti] ‘I sow, I plant’
[pahkawáʔti] ‘you (singular) sow, you (singular) plant’
[ipahkawáʔti] ‘he/she sows, he/she plants’
[apahkawáʔti] ‘we sow, we plant’
[pahkawaʔtisi] ‘you (plural) sow, you (plural) plant’
[ipahkawaʔkána] ‘they sow, they plant’

Written solution

Your task is to analyze these Chamicuro morphophonemic data and write up your results. For this first part of the problem we will be doing only a rule-based solution. The corresponding OT analysis will be assigned next. Your solution should include at the minimum the following items, not necessarily in this order:

Underlying representations

Posit underlying representations for all prefixes which you observe in the data, along with their corresponding glosses. You do NOT need to present UR’s for any roots, nor do you need to
worry about analyzing suffixes and/or alternations that take place at the ends of roots. In addition, defend your choice of underlying forms for these prefixes. That is, justify and explain why you posited the UR’s that you did.

**Rules**

For each morphophonemic process operating in these data (within prefixes and/or at the beginnings of roots), posit a rule typical of pre-OT generative phonology. State each rule both in prose and formally, using whatever type of notation or formal devices you deem most illuminating and explanatory.

**Crucial ordering**

If your solution needs to rely on any crucial rule orderings, demonstrate that they are necessary, with a correct and an incorrect derivation of illustrative examples. More than two rules at a time may be combined if appropriate. Try to state what type of relationship each pair of ordered rules is in (i.e., feeding, bleeding, etc.).

**Due date**

Your write-up of the solution is due at the beginning of the hour on Day 33. After I have collected all the write-ups that day, I will distribute a handout containing my version of the solution, as well as instructions for part 2 of this problem (the OT analysis).
Some key references:


Examples of positional privilege/licensing/neutralization (Steriade 1993, Selkirk 1994):

1. The presence of a greater repertoire of contrasts, including more marked contrasts, in certain positions, while a smaller, less marked, subset of the repertoire appears in the complement set of positions.

2. The existence of certain positions which “trigger” phonological processes, e.g., vowel harmony spreading from roots to affixes (Akan), or from root-initial vowels to those that follow (Shona, Turkish).

3. The existence of positions where segments are especially resistant to change, e.g., initial position in vowel hiatus (Casali 1997).

<table>
<thead>
<tr>
<th>Privileged domain</th>
<th>Non-privileged domain</th>
<th>Languages</th>
</tr>
</thead>
<tbody>
<tr>
<td>syllable onsets</td>
<td>syllable codas</td>
<td>German</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Russian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Polish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Slave</td>
</tr>
<tr>
<td>roots</td>
<td>affixes</td>
<td>Cuzco Quechua</td>
</tr>
<tr>
<td>long vowels</td>
<td>short vowels</td>
<td></td>
</tr>
<tr>
<td>stressed syllables</td>
<td>unstressed syllables</td>
<td>English</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Russian</td>
</tr>
<tr>
<td>initial syllables</td>
<td>non-initial syllables</td>
<td>Chamicuro</td>
</tr>
</tbody>
</table>

Illustrations

Slave coda debuccalization (Rice 1989, Lombardi 1995):
Cuzco Quechua (Parker and Weber 1996, Parker 1997):

Glottalized (ejective) and aspirated obstruents are restricted to lexical roots and are systematically prohibited in suffixes:

- $[\text{tanta}]$ ‘collection; combination’
- $[\text{t}^{\text{h}}\text{anta}]$ ‘old; used up; worn out’
- $[\text{t}^{\prime}\text{anta}]$ ‘bread’
- $[\text{tanta-kuna}]$ ‘collection-PLURAL’
- $[*\text{tanta-k}^{\prime}\text{una}]$ impossible

English vowel reduction in unstressed syllables (cf. a similar situation in Russian):

- $[\text{fówDəgræf}]$ ‘photograph’
- $[\text{fət}\text{h}^{\acute{a}}\text{grəfr}]$ ‘photographer’

Also in English, aspirated stops are generally restricted to stressed syllables.

Chamicuro’s maximal syllable template is $[\text{CCVX}]$ normally, but word-initial syllables may exceptionally contain a third consonant in the onset (Parker 1987, 1989):

- $[\text{pla.wa}]$ ‘long’
- $[\text{ih.ʃwa.keh.ta.si}]$ ‘dawn’
- $[\text{čkwaʔ.ti}]$ ‘guan bird’

Summary: “In circumstances of positional neutralization, it is always the perceptually non-prominent position which undergoes reduction, while the prominent positions preserve a full range of contrasts” (Beckman 1998:5).

Word onset effects in processing (Beckman 1997):


2. Word-initial material is most frequently recalled by subjects in a tip-of-the-tongue state (Brown and McNeill 1966).

3. Word onsets are the most effective cues in inducing recall of the target word in tip-of-the-tongue states (Freedman and Landauer 1996).
4. Mispronunciations are detected more frequently in word onsets than in later positions (Cole 1973, Cole and Jakimik 1978, 1980).

5. Mispronunciations in word onsets are less likely to be fluently replaced in a speech shadowing task than errors in later positions (Marslen-Wilson 1975, Marslen-Wilson and Welsh 1978).

Beckman’s proposal: “The high ranking of positional faithfulness constraints ... yields the result that features and/or contrasts in just those positions which are psychologically or perceptually salient are less susceptible to neutralization than in other locations which are not protected” (1997:8).

The general strategy:

(1) Faith(PositionX) » Markedness » Faith

Illustration:

Imagine a language similar to Chamicuro. The maximal syllable template is normally [CVC], so no tautosyllabic consonant clusters are permitted. However, in word-initial position (and only there), a second onset consonant is possible:

<table>
<thead>
<tr>
<th>Possible</th>
<th>Impossible</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV.CV</td>
<td>*CV.CCV</td>
</tr>
<tr>
<td>CVC.CV</td>
<td>*CVCC.CV</td>
</tr>
<tr>
<td>CCV.CV</td>
<td>*CCCV.CV</td>
</tr>
</tbody>
</table>

Faithfulness constraints:

**Max(σ₁)**

Every segment in the word-initial syllable in the Input must have a correspondent in the Output.

**Max**

Every segment in the Input must have a correspondent in the Output.

Markedness constraint:

**Complex**

No tautosyllabic consonant clusters are permitted in the Output: *CC]ₜ, *ₜ[CC
Positional faithfulness ranking:

(2) \[ \text{MAX}(\sigma_1) \rightarrow \text{*COMPLEX} \rightarrow \text{MAX} \]

(3) Input: /CCVCV/ | \text{MAX}(\sigma_1) | \text{*COMPLEX} | \text{MAX}  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. CV.CV</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. CV.CV</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. V.CV</td>
<td><em>!</em></td>
<td>**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Result: in word-initial syllables, it is better to preserve a complex onset than it is to delete a consonant.

(4) Input: /CVCVCCCV/ | \text{MAX}(\sigma_1) | \text{*COMPLEX} | \text{MAX}  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. CV.CV.CVC.CV</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. CV.CV.CCC.CV</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. CV.CV.CVC.CV</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. CV.CV.CV</td>
<td></td>
<td>**!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Result: in non-initial syllables, it is better to delete a consonant than it is to retain a complex margin. However, deletion is minimal, or only as much as is necessary to satisfy *COMPLEX. Thus the extra (gratuitous) violation of low-ranking MAX is still fatal in candidate (d). In other words, overkill is not tolerated. This is emergence of the unmarked (TETU, McCarthy and Prince 1994).

In languages where word-initial syllables are not exceptional (privileged), we would have the following ranking:

(5) \[ \text{*COMPLEX} \rightarrow \text{MAX}(\sigma_1), \text{MAX} \]

(6) Input: /CCVCV/ | \text{*COMPLEX} | \text{MAX}(\sigma_1) | \text{MAX}  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. CCV.CV</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. CV.CV</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. V.CV</td>
<td>**!</td>
<td>**(!)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other typical kinds of positional faithfulness constraints:

\text{MAXROOT}(voice): voicing must be retained in root segments
\text{MAXLONGVOWEL}(nasal): nasality must be retained in long vowels
\text{MAXONSET}(place): place features must be retained in onset segments
\text{MAX-}\sigma(high): height must be retained in a stressed syllable

etc.
An OT Account of Laryngealization in Cuzco Quechua*

Steve Parker

Classical phonemic accounts of Cuzco Quechua posit three distinct series of stops: plain, aspirated, and glottalized. Parker and Weber 1996 argue instead for a root-level feature of laryngealization governed by a small number of formal mechanisms. In this paper, the analysis is taken one step farther and it is shown that even greater explanatory power may be achieved by appealing to the model of Optimality Theory.

1. Introduction

The purpose of this paper is to present an account of glottalized and aspirated stops in Cuzco Quechua, spoken in Peru, within the framework of Optimality Theory (Prince and Smolensky 1993). The groundwork for this study was laid by Parker and Weber (1996), who basically described the facts and proposed an analysis of them in terms of autosegmental theory and Grounded Phonology (Archangeli and Pulleyblank 1994). I will first review the distribution of glottalized and aspirated segments (which I will henceforth group together under the common label ‘laryngealized’, as in Parker and Weber 1996). Having done so, I will then show how the same facts can be accounted for in terms of violable constraint ranking and interaction, the central premise of Optimality Theory.

2. Overview of Quechua phonology

Cuzco Quechua exhibits the standard five vowel inventory, /i e a o u/. Primary stress normally falls on the penultimate syllable of each word. If we ignore some minor complications, virtually all Quechua words can be exhaustively parsed with the maximal syllable template [CVC]. Consequently, word-medial consonant clusters are always heterosyllabic: /pis qa/ five. At the underlying level, vowel-initial syllables occur only word-initially, whereas all word-internal syllables must contain an onset. However, at the phonetic level all syllables must obey this Obligatory Onset Condition (Itô 1986). Quechua satisfies this constraint by epenthesizing a default word-initial [ʔ], just as many other languages do.

3. Distribution of laryngealized stops

In Cuzco Quechua, the voiceless stops (and affricate) /p t č k q/ may all be contrastively glottalized or aspirated. (/q/ is post-velar or uvular.) Thus, it is possible to find minimal pairs and triplets such as the following:

   (1) [tanta]   collection, combination
   [tʰanta]   bread
   [tʰanta]   old, used up, worn out

Because of contrastive examples such as these, classical phonemic accounts in the structuralist tradition posited the following twenty-six individual consonant phonemes for this language, including three distinct series of stops (Rowe 1950, Cusihuamán 1976:291):

*Thanks to Diamandis Gafos for insightful suggestions on an earlier version of this paper.
However, as Parker and Weber (1996) note, many previous authors have observed that the laryngealized stops are subject to extreme phonotactic restrictions. Thus, while the plain consonants listed in (2) may occur in onsets or codas, in roots or in suffixes, and more than once in the same root, laryngeal stops are limited by the following constraints:

(a) They occur only in roots, never in suffixes.
(b) They occur only in the onset position of the syllable, never in codas.
(c) When laryngealized consonants do occur, they are always the first syllable-initial stop of the root (or word, since there are no prefixes). Thus, forms such as the hypothetical *[poqʰa], in which the second stop is glottalized (rather than the first one), are systematically non-attested.
(d) They may occur only once per root. No Quechua root contains two aspirated stops or two glottalized stops. Furthermore, glottalization and aspiration are mutually exclusive in the sense that they never co-occur in the same root. Thus a word may have an aspirated stop or a glottalized one, but not both. The generalization is that laryngealization is restricted to one occurrence per root.
(e) Aspirated consonants and /h/ are mutually exclusive with respect to roots. That is, if a root contains an aspirated stop, it may not contain an /h/, and vice versa.
(f) Words containing glottalized stops always begin with a consonant. Whenever an ejective occurs in a reflex of a Proto-Quechua root that began with a vowel, in Cuzco Quechua the word begins instead with [h]. For example, the Proto-Quechua form for *how many? is *ayka, while in Cuzco it is [haykʰa].

Concerning these last two points, (e) and (f), I wish to clarify that /h/ is indeed a contrastive phoneme in Cuzco Quechua, despite its epenthetic nature in forms such as [haykʰa]. Thus, not all words that begin with an [h] contain a glottalized stop later in the root; for example, /hatun/ big, tall.

The following data illustrate the distributional patterns of laryngealized stops described in this section:

<table>
<thead>
<tr>
<th>(3)</th>
<th>pʰatay</th>
<th>to bite</th>
</tr>
</thead>
<tbody>
<tr>
<td>pʰatay</td>
<td>to explode, blow up</td>
<td></td>
</tr>
<tr>
<td>tʰantä</td>
<td>bread</td>
<td></td>
</tr>
<tr>
<td>tʰantä</td>
<td>old, used up, worn out</td>
<td></td>
</tr>
<tr>
<td>čʰäcu</td>
<td>treacherous, tricky</td>
<td></td>
</tr>
<tr>
<td>čʰäcu</td>
<td>ragged, tattered</td>
<td></td>
</tr>
<tr>
<td>kʰanka</td>
<td>rooster</td>
<td></td>
</tr>
<tr>
<td>kʰanka</td>
<td>slimy, clammy</td>
<td></td>
</tr>
<tr>
<td>qʰata</td>
<td>turbid, muddy</td>
<td></td>
</tr>
</tbody>
</table>
The obvious conclusion to draw from these facts is that laryngealization in Cuzco Quechua is not a characteristic of individual phonemes, but rather of entire roots. Thus, Parker and Weber (1996) account for these facts in a principles and parameters model by positing the features [constricted glottis] (CG) and [spread glottis] (SG) as floating root-level autosegments which dock by rule to the leftmost syllable-initial stop in the word. This allows us to drastically simplify the phonemic inventory in (2) by eliminating the two series of laryngealized obstruents. Furthermore, as Parker and Weber (1996) point out, the distributional quirks of laryngealized roots with respect to the phoneme /h/ can also be explained as an effect governed by the Obligatory Contour Principle (OCP), as we shall see in the following sections.

4. OT analysis

In this section I will recast the Parker and Weber (1996) analysis in terms of Optimality Theory. Much of the basic groundwork has been laid already by McCarthy (1996). I will draw from his account here and then modify and expand it in order to handle all of the interactions of laryngeal features in Cuzco Quechua.

4.1. Licensing [constricted glottis] and [spread glottis]

In the first place, we must obviously account for the fact that the features [constricted glottis] and [spread glottis] surface only on stops and in isolation. This can be accomplished by stipulating the structural conditions for these features as follows:
(4) LicenseCG (LicCG)
   The feature [cg] is licensed only in isolation or in conjunction with the following configuration:

   \[ \text{[–sonorant]} \]
   \[ \text{[–continuant]} \]

(5) LicenseSG (LicSG)
   The feature [sg] is licensed only in isolation or in conjunction with the following configuration:

   \[ \text{[–sonorant]} \]
   \[ \text{[–continuant]} \]

The addition of “in isolation” to the licensing constraints for [sg] and [cg] is needed in order to allow a phonemic /h/ to surface, and not just aspirated stops. Likewise, the default epenthetic onset [?] needs to be permitted to surface independently of ejectives. As McCarthy 1996 shows, these two constraints must dominate the corresponding MAX constraints in order to filter out hypothetical underlying forms containing laryngealized sonorants (cf. the “richness of the base” principle of OT):

(6) | UR: /m\text{̄}aru/ | LicCG | MAXCG |
    | a. \text{̄}aru [maru] | * | |
    | b. [m\text{̄}aru] | ! | |

The tableau above establishes the ranking of LicCG over MAXCG. Thus the hypothetical underlying glottalization on a sonorant will never surface since high-ranking LicCG compels deletion of this feature in violation of the lower-ranked faithfulness constraint. Comparable arguments could be given for the interaction of aspiration features (LicSG \gg MAXSG) as well. For the sake of brevity I will not duplicate all of these details in the ensuing discussion, but will instead use ejectives as examples of how we could deal with aspirates in an analogous way. Therefore, constraints which refer to the feature [constricted glottis] should also be understood as referring to the feature [spread glottis].

4.2. Alignment constraint

In order to account for the fact that laryngealization is always attracted to the leftmost stop in a word, McCarthy 1996 posits an alignment constraint which we can express as follows:

(7) ALIGNCG
   Align the feature [cg] with the left edge of a prosodic word.
   Align(CG,L,PrWd,L).

The interaction of this markedness constraint with the others already discussed is illustrated in the following tableau as applied to the word /\text{̄}uk\text{̄}u/ withered:
Candidate (b) [ñuku] attempts to satisfy ALIGNCG by shifting the glottalization to the word-initial /ñ/. However, this incurs a fatal violation of LICCG, as we have already seen. Candidate (c), however, resorts to a different strategy in order to resolve the misalignment: it deletes the laryngealization altogether. This violates MAXCG, so [ñuku] is also a non-optimal output for this underlying form. The fact that the completely faithful candidate (a) [ṅuku] is the one which correctly surfaces is an indication that ALIGNCG is ranked below MAXCG, as I have shown in this tableau. Thus, perfect alignment can be sacrificed in order not to violate higher ranked constraints, specifically LICCG and MAXCG. As McCarthy points out, while the ALIGNCG constraint dictates that glottalization will show up as far left in the word as possible (all other things being equal), this does not mean that laryngealization will necessarily fall on the word-initial segment in all cases. On the contrary, as we have seen, if the leftmost potential anchor is not a stop or affricate, high ranking LICCG will block glottalization from surfacing on that segment.

It is crucial in this case to count violations of ALIGNCG in a gradient rather than a categorical fashion, since otherwise we could not select between candidates in which glottalization surfaces on the second rather than the third syllable of the root. For example, given a hypothetical underlying form such as /rankuk'uy/ (cf. [rank] to get twisted up), Cuzco Quechua requires that the leftmost stop be the one which surfaces laryngealized. This is accomplished in the following tableau since candidate (a) [rankuk'uy] receives three marks under ALIGNCG for the segments /ran/ which separate the ejective from the beginning of the word. However, totally faithful candidate (b), [rankuk'uy], violates alignment five times and thus fails to survive:

<table>
<thead>
<tr>
<th>UR: /rankuk'uy/</th>
<th>LICCG</th>
<th>MAXCG</th>
<th>ALIGNCG</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [rankuk'uy]</td>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>b. rankuk'uy</td>
<td></td>
<td></td>
<td>*******</td>
</tr>
</tbody>
</table>

4.3.  A constraint inhibiting the shifting of laryngealization

Another constraint which McCarthy also considers is STAYCG. This constraint inhibits the shifting of laryngealization from its underlying locus to some other segment in the word. As the following tableau demonstrates, STAYCG must be ranked below ALIGNCG, since the latter needs to compel a violation of the former in the case of hypothetical underlying forms such as /pat'ay/ (cf. [p'atay] to bite):

<table>
<thead>
<tr>
<th>UR: /pat'ay/</th>
<th>ALIGNCG</th>
<th>STAYCG</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [p'atay]</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. pat'ay</td>
<td></td>
<td>1*</td>
</tr>
</tbody>
</table>

Here the correct surface form [p'atay] violates STAYCG in order to perfectly satisfy ALIGNCG, and so is the most harmonic candidate. The loser [pat'ay] maintains the glottalization on its underlying anchor, but in doing so fatally violates alignment. (In this case the higher ranking
4.4. Coda filter

As I indicated in §3, another crucial restriction on the distribution of laryngealized stops in Cuzco Quechua is that they systematically never occur in syllable-final position. I would explain this typical example of coda neutralization by pointing out that aspirates and ejectives both involve a high intensity, fortis airstream in their articulation, whereas syllable-final position corresponds to a tapering out of the airstream after the nuclear pulse. We can thus incorporate this insight into our formal analysis by borrowing a constraint posited independently by Lombardi (1995):

(11) AlignLaryngeal (ALIGNLAR)
    Align a Laryngeal Node with the left edge of a syllable.
    Align(Laryngeal, L, σ, L).

This constraint requires any segment bearing a Laryngeal Node to occur in syllable-initial position. This formalization is crucially based on the assumption that all segments besides ejectives, aspirates, and /h/ are underspecified for laryngeal features, including [±voice], since these are otherwise not contrastive in the language (obstruents are uniformly voiceless while sonorants are voiced). Since phonemic /h/ does not occur syllable-finally in Cuzco Quechua either, the ALIGNLAR filter (11) captures the relevant generalization. This constraint is undominated in this language since no other pressure, even MaxCG, can compel it to be violated. Thus, consider a hypothetical underlying form such as /raktʰa/ (cf. [raktʰa] thick):

(12)

<table>
<thead>
<tr>
<th>UR: /raktʰa/</th>
<th>ALIGNLAR</th>
<th>LicCG</th>
<th>MaxCG</th>
<th>ALIGNCG</th>
<th>StayCG</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. raktʰa</td>
<td>#*#</td>
<td></td>
<td>***</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. rakʰta</td>
<td>*!</td>
<td></td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. rʰakta</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>d. rakta</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

As demonstrated by tableau (12) above, regardless of where laryngealization is located in a root underlyingly, the postulated constraint ranking will ensure that it correctly surface on the leftmost syllable-initial stop, as we desire. Thus, the winning candidate [rakʰta] violates only low ranking ALIGNCG and StayCG, whereas the perfectly faithful candidate (b), [rakʰta], fatally violates the undominated ALIGNLAR filter. Candidates (c) and (d) avoid misalignment but in doing so they fall victims to other higher ranked constraints.

4.5. Root faithfulness

The final detail which McCarthy discusses is the fact that laryngealization in Cuzco Quechua is restricted to roots and thus never occurs in suffixes. (Quechua languages have no prefixes.) He accounts for this common dichotomy by positing a markedness constraint, *CG, which prohibits glottalized segments. This constraint dominates MaxCG, but at the same time is dominated by MaxRootCG (preserve a CG specification if it occurs in a root). The following tableau illustrates this analysis for the words [tʰanta] bread and [tanta-kuna] collections:
In the word [tʰantə] above, the totally faithful candidate (a) wins since its root-initial ejective is maintained. This violates *CG, but the alternative is to delete this feature and thus fatally lose on the higher ranked MAXROOTCG, (candidate (b)). The opposite situation obtains with a hypothetical underlying form such as /tanta-kʰuna/, where [-kuna] is a pluralizing suffix. Here the glottalization on the /kʰ/ is no longer “protected” by MAXROOTCG since it is in an affix. Consequently, *CG kills the totally faithful candidate (b), whereas the winning [tanta-kuna] only violates low ranked MAXCG. In order to be technically correct, I could have included MAXROOTCG and *CG in my earlier tableaux. However, since the same outcomes would result regardless of this fact, I will continue to leave them out for the sake of simplicity.

### 4.6. Obligatory Onset

I now consider the fact that all syllables in Cuzco Quechua obey the Obligatory Onset Condition. Recall that forms which begin with a vowel underlyingly receive a default word-initial [?] in order to satisfy this requirement. In situations like this the [?] is normally considered only a transitional phonetic reflex which plays no active role in the phonology of the language. As we shall observe shortly, however, there is evidence that these [?]’s in Cuzco Quechua are crucially sensitive to certain important constraints.

The presence of epenthetic [?] can be enforced by assuming that ONSET is high ranked, such that it compels violation of DEP (Dependency). ONSET here is the well-known prohibition against vowel-initial syllables, and DEP inhibits the presence of features and/or segments in the output which were not present in the input (i.e., it inhibits epenthesis). The specification of [?] as the default consonant can be achieved by the familiar strategy of ranking *PHARYNGEAL below the prohibition against all other place nodes:1

(14) *Labial,*Dorsal }} *Coronal }} *Pharyngeal

The ranking of *LABIAL and *DORSAL above *CORONAL is posited, based on universal patterns of markedness without any specific empirical evidence in Cuzco Quechua. In the markedness hierarchy (14) above, the default epenthetic consonant of choice will be a pharyngeal. However, this leaves open the question of how to enforce the selection of [?] over [h]. Perhaps the simplest solution would be to split *PHARYNGEAL into two more specific constraints, *SG and *CG. However, as Diamandis Gafos (p.c.) has pointed out to me, this ranking is highly stipulatory and does not follow from any independently motivated facts. A better solution would be to rely on Clements’ (1990) proposal for a Sonority Dispersion Principle (SDP). Basically this constraint requires that we maximize the sonority slope from onset to nucleus and minimize it from nucleus to coda. Since [?] (a stop) is lower in sonority than [h] (a fricative), the Sonority Dispersion Principle

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1 Here I am using the cover term ‘pharyngeal’ to include glottal consonants as well, in keeping with a growing body of recent literature. For example, see Prince and Smolensky 1993 and Kenstowicz 1994 (pp. 456-457, citing McCarthy 1991).

<table>
<thead>
<tr>
<th>UR: /tʰantə/</th>
<th>MAXROOTCG</th>
<th>*CG</th>
<th>MAXCG</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. tʰantə</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. tanta</td>
<td>![ ]</td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UR: /tanta-kʰuna/</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. tanta-kʰuna</td>
</tr>
<tr>
<td>b. tanta-kʰuna</td>
</tr>
</tbody>
</table>
Steve Parker

will choose [ʔ] over [h] as a preferred onset when all other factors lead to a tie. Below I illustrate the interaction of these constraints for the word [ʔasikuy] to laugh:

(15)  
<table>
<thead>
<tr>
<th>UR: /asikuy/</th>
<th>ONSET</th>
<th>DEP</th>
<th>*LAB,*DOR</th>
<th>*COR</th>
<th>*PHAR</th>
<th>SDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ʔasikuy</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. asikuy</td>
<td>!</td>
<td>*</td>
<td>**</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. tasikuy</td>
<td>*</td>
<td>*</td>
<td>**</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. hasikuy</td>
<td>*</td>
<td>*</td>
<td>**</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the tableau above, the winning candidate [ʔasikuy] violates DEP due to the insertion of a word-initial [ʔ]. This is tolerated, however, since it satisfies top-ranked ONSET, whereas totally faithful [asikuy] fails in this respect. All of the candidates share in common two violations of *DOR (one for the /k/ and one for the /y/) and one of *COR (for the /s/). In addition, [tasikuy] entails a second and fatal violation of *COR whereas [hasikuy] and [ʔasikuy] equally violate the low-ranked *PHAR. However, since [ʔasikuy] begins with a (voiceless) stop, its initial onset-nucleus sonority slope is perfectly maximized, whereas the initial fricative in [hasikuy] fatally violates the Sonority Dispersion Principle. Thus, [ʔasikuy] emerges as the correct winning candidate.

4.7. An OCP effect

We now come to the interesting stipulation that no root in Cuzco Quechua may contain two ejectives, two aspirates, or an aspirated stop plus an /h/. As Parker and Weber (1996) argue, these examples of root co-occurrence limitations are prototypical OCP effects. Thus, we can account for these phenomena by positing that in this language the OCP constraint dominates MAXCG and MAXSG (or, more precisely, MAXROOTCG and MAXROOTSG) because it requires unfaithful deletion in those cases in which Gen supplies an input containing two identical laryngeal specifications. Consider as an example the hypothetical underlying representation /qʔatʔa/ (cf. [qʔata] muddy):

(16)  
<table>
<thead>
<tr>
<th>UR: /qʔatʔa/</th>
<th>OCP</th>
<th>MAXCG</th>
<th>ALIGNCG</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ʔqʔata</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. qʔatʔa</td>
<td>!</td>
<td>*</td>
<td>**</td>
</tr>
<tr>
<td>c. qʔata</td>
<td>*</td>
<td>*</td>
<td>*!</td>
</tr>
<tr>
<td>d. qata</td>
<td>**!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The winning candidate [qʔata] obeys the OCP by deleting the glottalization on the second stop and thus only violates MAXCG. Candidate (b), on the other hand, faithfully preserves both underlying ejectives but in doing so fatally violates top-ranked OCP. Candidate (c) is similar to (a) in that it maintains only one occurrence of [cg]; but (c) violates ALIGNCG since it preserves glottalization on a non-initial stop. Finally, candidate (d) is not optimal because its double deletion of the underlying glottalization violates MAXCG twice.

In the following tableau I give a further example illustrating the interaction of these constraints with the feature [sg] for the hypothetical underlying form /huqʔari/ (cf. [huqari] to lift):

---

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In this case candidate (a) is correctly predicted to win, for the same reasons as with tableau (16). However, what is interesting is that the cognate form of this word in Bolivian Quechua, a closely related dialect, is [uqʰari], candidate (c). In this latter form the potential OCP violation is avoided by leaving off the word-initial [h] rather than by de-aspirating the /qʰ/. In order to derive this outcome some additional constraint would be needed. I do not know if Bolivia Quechua even has the phoneme /h/, or perhaps it does not license it word-initially. Perhaps a solution along these lines would work; I will not pursue the matter here.

I am now in a position to account for the fact that the default epenthetic onset in glottalized roots surfaces as [h] rather than [ʔ]. This can be seen as another case of OCP blockage on the [cg] tier (Parker and Weber 1996). Assuming that the OCP and ONSET constraints are undominated in Cuzco Quechua, observe the evaluation of the following set of candidates for /aykʰa/ → [haykʰa]

**How many?:**

In tableau (18), the high ranking ONSET constraint compels initial epentheses. Since the totally faithful candidate (b), [aykʰa], does not fulfill this requirement, it is immediately knocked out of the running. Candidate (c), [ʔaykʰa], has the normally expected default onset [ʔ], but since an ejective occurs later in the root, the introduction of this segment violates the OCP. Candidate (a), [haykʰa], however, avoids this problem by epenthesizing an [h] rather than a [ʔ]. Since this violates only the lower ranked *PHAR and SDP constraints, [haykʰa] is correctly selected as the most harmonic output. Candidates (d) and (e) attempt to sidestep the potential OCP violation by deleting the [cg] feature on the underlying ejective. This violates the faithfulness constraint MAXROOTCG, sealing their fate as non-optimal forms. As Parker and Weber (1996) note, the insertion of a word-initial [h] in glottalized roots can thus be seen as a dissimilation process triggered by the OCP. Epenthetic [ʔ] and [h] are in complementary distribution in this language; the undominated requirement for an onset leads to a default [ʔ] in most cases since *PHAR is at the bottom of the markedness hierarchy for consonants. However, when the high ranking OCP would be violated (and only then), [h] appears instead. One aspect of this analysis which is theoretically significant is that word-initial [ʔ]’s are normally considered to be nothing but a transitional phonetic reflex, especially when there is no corresponding /ʔ/ phoneme in the language. In Cuzco Quechua, however, this postlexical segment crucially interacts with independently-needed phonological constraints such as the OCP in a unique and interesting way.
5. Conclusion

In this sketch I have outlined an account of laryngealization in Cuzco Quechua in terms of Optimality Theory. Perhaps the most interesting detail of the analysis is a Panini or Elsewhere type of interaction between [ʔ] epenthesis and [h] epenthesis. These latter processes provide additional confirmation of the fact that Pharyngeal, not Coronal, is the universally unmarked place node for default consonants.

Appendix: Ranking of constraints

```
ALIGNLAR, LICCG, LICSG  OCP  ONSET

MAXROOTCG, MAXROOTSG

*LAB, *DOR  DEP

*COR

*CG, *SG, *PHAR, SDP

MAXCG, MAXSG

ALIGNCG, ALIGNSG

STAYCG, STAYSG
```
References


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How many constraints are there? A preliminary inventory of OT phonological constraints

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ABSTRACT

In this project we document a total of 1666 unique OT constraints published in the phonological literature. These span a period of time from 1993 through 2008 and come primarily from four major journals. The main constraint database contains the following information for each entry: name, abbreviation, type, subtype, definition, violation example, comments, author, year, and journal. This catalog is presented all together in a single Excel spreadsheet, allowing the user to quickly find and sort constraints based on a number of individualizable parameters. In this paper we also include a summary analysis of the quantity of constraints divided according to three independent variables: type, date of publication, and source.

1. Introduction

A commonly-heard question among students of OT, especially beginners, is “How many constraints are there?” This project represents an initial attempt to provide a principled and systematic (albeit indirect) answer to that query. In this paper we describe the design of an accompanying constraint inventory contained in an Excel spreadsheet (constraint catalog.xls). Here we list and explain the column headings used to organize that document. We also sketch the history behind it, summarize the results we obtained, and provide some preliminary statistical analysis and discussion.

The main purpose of this work then is to document all of the formal phonological constraints that have been proposed and used in a substantial corpus of the OT literature. This will allow practitioners of OT to search for constraints based on a number of powerful and useful parameters such as name, type (markedness, faithfulness, etc.), definition, subtype (phonotactic, tonal, metrical, etc.), author, year, journal, etc. Consequently, it is now possible to provide a rigorous answer to several intriguing and potentially important issues such as the following:

(1) a. In what year was a given constraint first proposed, where, and by whom?
   b. How many specific, individual distinctive features have been the target of faithfulness constraints of the type IDENT(ft)? (Our answer: 27.)
   c. How many constraints has a particular author (e.g. Alan Prince) proposed? (Our answer: Alan Prince has been involved in proposing at least 151 constraints.)
   d. During the history of OT, has the average number of new constraints proposed each year gone up or down overall? (Our answer: up.)
   e. How many functionally-different definitions are there of the constraint called NONFINALITY? (Our answer: 10.)
   f. In which journal did the mechanism of local constraint conjunction first appear in print? (Our answer: Linguistic Inquiry.)
   g. What proportion of all constraints is of the markedness variety? (Our answer: 54%. To
a certain degree of course the answer to this question depends on how one defines a markedness constraint, as well as how certain types of constraints (such as general schemas for families of related constraints) are counted. See §4.3-4.4 for further discussion and clarification.)

With respect to the questions posed in (1), as well as the answers we provide, a few comments are in order. From a theoretical point of view the list of constraints appearing in our database is somewhat arbitrary rather than unified. By this we mean that no attempt has been made to ensure that the constraints included here are necessarily compatible with each other. Rather, any number of different models and subversions of OT are freely mixed together, with little discrimination between them. Consequently, many of the cited works not only propose their own constraints but reject certain others. For example, McCarthy’s (2003b) paper on categorical constraints repudiates many of the gradient alignment constraints that he himself originally invented. Hence there is undoubtedly no variety of OT which would accept all the constraints in our list as being simultaneously viable as part of one single theory.

At the same time, however, we still believe that this project is very worthwhile. We hope that it will serve as a helpful methodological tool in evaluating the validity of general assertions about OT. For example, any claim about the capabilities of a universal constraint set depends on all the members of CON. Our list provides an efficient way for theoreticians to make sure they have considered all extant constraints when considering the typological ramifications of their new proposals. It also has practical value in helping researchers know where to start in documenting references to work about OT.

The remainder of this paper is organized as follows. In §2 we present an overview of our findings. In §3 we note the criteria used to narrow down the sample of sources for this project. In §4 we list and explain each field (column) appearing in our database. In §5 we provide some preliminary statistical analysis and discussion of our results. In §6 we briefly review a few previous lists of OT constraints and compare them with our own. Finally, in the conclusion we reflect on some of the implications of this work.

2. Overview of results

In this section we present an initial summary of the types of statistical generalizations discussed in more detail later in the paper (§5). In response to the main issue of how many constraints exist overall, we can now offer the following conclusion. In a tightly-controlled sample consisting of four major linguistic journals plus four other seminal OT works (§3), ranging between the years 1993 and 2008, the total number of unique, newly-proposed phonological constraints is 1666:
Table 1: Overall numbers of constraints in our entire sample, distinguished by type, and displayed in decreasing order of frequency

<table>
<thead>
<tr>
<th>constraint type</th>
<th>number</th>
</tr>
</thead>
<tbody>
<tr>
<td>markedness</td>
<td>902</td>
</tr>
<tr>
<td>faithfulness</td>
<td>492</td>
</tr>
<tr>
<td>alignment</td>
<td>241</td>
</tr>
<tr>
<td>local conjunction</td>
<td>11</td>
</tr>
<tr>
<td>other/miscellaneous</td>
<td>11</td>
</tr>
<tr>
<td>antifaithfulness</td>
<td>9</td>
</tr>
<tr>
<td>total</td>
<td>1666</td>
</tr>
</tbody>
</table>

All of the details related to classifying these constraints into the six categories in Table 1 are fully fleshed out in §4.3 and 5.1. For example, in this tabulation we have chosen to make a split between markedness and alignment constraints. This is certainly not necessary, although it does have precedents in the literature, e.g., Kager (1999:451-52). For someone interested in alignment as a specific topic, this should prove useful. Otherwise, it is a trivial matter to lump these two categories together if one wishes to underdifferentiate them. A complete breakdown of all 1666 individual constraints by type, source, and the year they were first proposed is provided in the Appendix to this document. The table there allows us to group, compare, and contrast the numbers of constraints by factors such as the journal in which they appeared. When we do this we discover that, not surprisingly, *Phonology* is at the top of the list. The following table ranks four major journals in terms of the numbers of new constraints they contain:

Table 2: Overall numbers of constraints in our sample, distinguished by journal, and displayed in decreasing order of frequency

<table>
<thead>
<tr>
<th>journal</th>
<th>number of constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phonology</td>
<td>558</td>
</tr>
<tr>
<td>Linguistic Inquiry</td>
<td>371</td>
</tr>
<tr>
<td>Natural Language &amp; Linguistic Theory</td>
<td>340</td>
</tr>
<tr>
<td>Language</td>
<td>261</td>
</tr>
<tr>
<td>total</td>
<td>1530</td>
</tr>
</tbody>
</table>

In Table 2 the total number of constraints taken from these four journals is 1530. This is less than the total number of constraints appearing in our entire exhaustive sample (1666 in Table 1). This is because we supplemented these four journals with a few other major OT works in order to make our constraint inventory more complete and representative of the field. See §3 and 5.2 for further discussion.

Finally, another statistical measure we can also pursue is the number of constraints distinguished by date. Among the four journals listed in Table 2, the fewest new constraints \( n = 34 \) were proposed in 1995, the first year in which articles on OT appear in this venue. The most prolific year is 2008 (209 new constraints). On average the proportion of new constraints proposed in the span between 1995 and 2008 increases overall by about 30\% per year. From this...
fact we conclude that, despite frequent claims to the contrary, OT is still very much alive and well.

3. The sample of sources

In this section we explain the criteria used to restrict the corpus of works we examined in searching for constraints to document. As noted in §1, our overall goal in this project is to compile a list of phonological constraints that is more or less exhaustive, within a well-defined sample of published works representing a selective yet robust subset of the OT literature. The group of journals we decided to review is the following four, arguably the most prestigious ones in the field (cf. Table 2):

(2) The four journals included in our sample, with the corresponding abbreviations used in our database

- *Phonology* (Phono)
- *Linguistic Inquiry* (LI)
- *Natural Language & Linguistic Theory* (NLLT)
- *Language* (Lang)

There certainly exist other established journals which also publish significant articles on OT and are therefore worthy of consideration. However, the time frame in which we carried out the groundwork for this study was limited, so we had to narrow down the corpus to a logistically manageable set. Specifically, this research was conducted as a course project lasting for eight weeks during the fall bimester of 2009. Consequently, we could not reasonably take on more journals than these four. Furthermore, at that moment of time none of these journals had yet released its final issue for calendar year 2009. Therefore, in order to establish a consistent, a priori stopping point, we scanned the four selected journals through the final issue of each one up to the 2008 volumes only. We began searching these journals with the 1993 volumes. Nevertheless, as foreshadowed in §2, the first year in which OT articles appear in any of them is 1995 (see the Appendix). Therefore, in order to round out this survey with all of the foundational constraints, we supplemented the journals with four other seminal OT works. The latter are the original sources for many of the most important and commonly-invoked constraints at the beginning of the OT period (and some of these constraints are still in use today). These four monographs were widely-circulated at the time, in various stages of revision and (pre-) publication:

(3) Four important pieces of early OT literature not found directly in the journals we scanned


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1This course, called “Frontiers in Phonology”, was taught by Steve Parker at GIAL. The other eight co-authors of this paper were all students in that course.

The complete bibliographic details of these four works are found in the list of references at the end of this paper. We also include there an entry for each article on OT from the four journals that we surveyed. Consequently, our bibliography amounts to an essentially exhaustive list of all the papers on OT phonology published in the four major journals between the years 1995 and 2008, inclusively. However, a note of clarification is in order. An important issue is, what counts as a “paper on OT phonology”? The answer to this is necessarily somewhat subjective. Many articles mention OT only in passing, or in order to criticize and reject it, etc. Works of this sort are normally not included here. Rather, in order to limit our corpus to all and only those papers which are “OT-friendly,” we adopted the general working criterion of including an article in our survey iff it contains at least one tableau. Nevertheless, we sometimes loosened this guideline and included a specific constraint from a paper not having a tableau, if it appears from the context to be a serious proposal (as further defined below). Similarly, in our constraint catalog we strive to document only those constraints which the author(s) intend to represent the final, official, formal versions of their analysis. Therefore, we purposely exclude here those constraints which the authors identify as preliminary, informal, tentative, speculative, to-be-rejected, temporary, ad hoc, brute force, etc. In other words, we have taken pains to keep our list of constraints as theoretically cogent and compelling as possible. At the same time, however, we have intentionally left out of this study just a few OT works which are very important, yet orthogonal to our purposes. For example, in focusing on the question of what makes a feasible (valid) constraint, Potts and Pullum (2002) elucidate a number of interesting and significant issues. Nevertheless, most of the constraint definitions they posit are restatements of previously-proposed constraints using the more formal and restrictive devices of extensible modal logic. Since these newer definitions do not generally affect how these constraints have been used in actual practice, we have chosen not to include Potts and Pullum (2002) in our survey, despite the undeniable contribution their work makes to the theory overall.

Another related issue is that we have limited our inventory of OT constraints to those which are phonological in nature only. Thus, we have intentionally avoided constraints pertaining strictly to syntax, semantics, etc., such as STAY, which militates against traces and therefore movement in general (Grimshaw 1997, McCarthy 2008a). Once again this distinction is sometimes hard to navigate, but in general we err on the side of inclusivity. That is, we have opted to include here any constraint referring in some way to phonological features, structures, or representations, even though the rest of the constraint definition may technically lie in another realm. For example, one subtype of constraint we do document in our catalog is the family of phonosyntactic WRAP-XP constraints originally proposed by Truckenbrodt (1995, 1999).

Finally, we close this section by discussing another well-known repository of OT works, the Rutgers Optimality Archive (ROA). This is also a logically-organized and important subset of the OT literature which could have potentially been selected as an alternative sampling base for a work of this sort. Initially we did in fact consider this as one option to pursue. The ROA has some distinct advantages vis-à-vis the journals. One obvious strength is that it is more inclusive, in the sense that it contains works such as theses, dissertations, etc., which are too big for journals. Furthermore, it includes many good papers which, for one reason or another, have not (yet) made it into the paper journals. A second advantage of the ROA is that it is free (modulo
Internet access) and therefore available in more places to more people. At the same time, however, these very factors can also be seen as a disadvantage of the ROA. Many of the works posted on it are preliminary working drafts designed to solicit feedback from the field. The four journals we surveyed, on the other hand, are well-established venues characterized by a rigorous and highly-competitive peer review process, ensuring theoretical respectfulness. This is normally lacking on the Archive. In the end we made this criterion — scientific precision rather than inclusiveness — our main priority and thus opted for the four journals. Another factor that confirmed this decision is logistical: it would have taken too long to survey every item posted on the ROA. In summary, then, all of the constraints contained in our catalog come from one of two sources: either (a) the four journals listed in (2), ranging between the years 1995 and 2008, or (b) the four additional works listed in (3). What is more, all of the constraints we document here relate specifically to phonology, to one degree or another.

4. Description of the constraint catalog

In this section we describe and explain the general organization of our constraint inventory in terms of the various fields (columns) used to annotate it. As noted in §1, the list of constraints is contained in the Excel file called constraint catalog.xls. In the comments here we introduce and discuss the individual parts of each entry, one-by-one, following the left-to-right order in which they appear in the first row of that document.

Both in this paper and in our Excel database, the default typeface font we use is Times New Roman. This is standardly included in all Microsoft Office applications. However, in order to display special phonetic characters which do not appear in the basic Office packages, we use the Doulos SIL unicode-compliant font. This will need to be installed in order to read the constraint spreadsheet correctly. This font is available for free download from the SIL International site: http://www.sil.org/computing/catalog/show_software.asp?id=91. Furthermore, it is important to note here that in our constraint entries we normally follow the transcription conventions of each source. Therefore, it is definitely not the case that we consistently transcribe all phonetic characters using the IPA system only.

Throughout the whole database we tend to follow a couple of general conventions in the interest of saving space. Specifically, to make the data as compact as possible, we leave out spaces between words when this does not obscure the meaning. We also substitute the ampersand symbol (&) for the word and whenever possible. These adjustments are made especially in conjunction with the first column in the constraint catalog (the constraint name; see §4.1). However, we often employ them elsewhere as well, i.e., in other fields.

4.1 Name (column A)

This cell displays the official name of the constraint, as specified by the author. Usually this is taken from the point in the article where the constraint is first introduced and discussed. In some cases, however, the author initially considers a loose version of the constraint in question but later rejects it. In these situations we just give the final name of the constraint which the author ultimately settles on. In entering our data into the spreadsheet we strove to make our task as typists as easy as possible. Therefore, we do not format the constraint names with the small caps font typically used for non-initial letters in the published literature. Rather, we capitalize the first letters of all major words and just enter all other letters as regular lower case.
4.2 Abbreviation (column B)

In this column we give the abbreviation for the corresponding constraint name listed in the cell to the left (in column A). We do not make up any of these abbreviated names ourselves, but strictly follow the abbreviations employed by the authors, such as in a tableau. In the numerous cases when the original author does not utilize an abbreviated name for a newly-proposed constraint, we just leave this cell blank.

4.3 Type (column C)

In this column we list the major type or variety of each constraint, following the six-way classification scheme outlined in Table 1. In many cases when we were unsure of the appropriate category for characterizing a constraint, we consulted the original source and followed its classification. See §5.1 for further discussion of this point. The current, default order of appearance of all constraints in our catalog is sorted by this field (type). Therefore all faithfulness constraints are grouped together in one block, all markedness constraints are listed consecutively in one block, etc. The six classes of constraints are arranged alphabetically, so they appear in the following order:

(4) Linear (top to bottom) order in which the six categories of constraints are listed in our database, and their corresponding abbreviations

a = alignment
af = antifaithfulness
f = faithfulness
lc = local conjunction
m = markedness
o = other/miscellaneous

Within each of these six groups the individual constraints are sorted next by name (column A), following Excel’s default parameters for alphabetization. Thus, for example, the markedness constraint called *GEMINATE appears earlier in our list than the markedness constraint AGREE(place).

We now explain and clarify how we define the six-way typology of constraints in (4) for the purposes of this project. Alignment (a) and antifaithfulness (af) types are self-explanatory, so we have simply used these two labels as they are commonly understood in the OT literature. For faithfulness (f) constraints we assume the default type to be input-output (IO), following McCarthy and Prince (1995). Consequently, in most cases we have intentionally left this annotation out of the constraint names and abbreviations in columns A and B, respectively. For other varieties of faithfulness constraints, however, we include the standard subcategorization provided by the source. This includes base-reduplicant (BR), output-output (OO), etc. When no such abbreviation is given in columns A and B, faithfulness constraints can be assumed to be of the IO variety.

The abbreviation lc in column C of the spreadsheet stands for local conjunction. This is followed by a colon and then the abbreviations for the names of the two more basic types of constraints which are being combined. For example, entry #752 is named [*s/SON≥e,o &
IDENT(high)]. We classify this as a local conjunction of the markedness constraint *\( \delta /\text{Son} \geq e,o \) ([e,o] must not belong to an unstressed syllable) plus the (input-output) faithfulness constraint IDENT(high) (output correspondents have the same specification for high as the input). Consequently, the type (column C) for this entry is \( lc:m/f \), which means the local conjunction of a markedness constraint and a faithfulness constraint.

Constraints of the type \( (m) \) are markedness. In this category we include not only “pure” markedness constraints such as *\( \text{Vo} \text{iObs} \) (voiced obstruents are prohibited), but also many other subvarieties of constraints such as those which are sometimes referred to as “structural” in nature.

The constraint type abbreviation \( (o) \) stands for other/miscellaneous (see (4)). This is a small, residual set of hodge-podge constraints which do not fit nicely into any of the other five categories. One such example is Padgett’s (2003) family of dispersion theory paradigmatic constraints, e.g., \( \text{Space(color)} \geq 1/3 \), which dictates that “potential minimal pairs differing in vowel color (backness and roundness) differ by at least \( \frac{1}{3} \) of the full vowel color range.” This is entry #1665 in our catalog. In general we have tried to use the type \( (o) \) sparingly, pushing constraints into one of the other five canonical groups whenever possible. Hence there are only 11 entries of type \( (o) \) in our inventory. In contrast to this we have used the type markedness \( (m) \) very liberally, preferring to label ambiguous constraints as type \( (m) \) rather than \( (o) \) in most cases. Given the alphabetical order of these six constraint categories, the other/miscellaneous group \( (o) \) appears at the very end (bottom) of the Excel spreadsheet.

4.4 Subtype (column D)

In this column we give a more specific idea of what type of linguistic element, level, or structure is being referred to by each constraint. For example, both the markedness constraint *\( \text{Vo} \text{iCE} \) and the antagonistic faithfulness constraint IDENT(voice) are annotated in this column as featural. Every constraint in the database has at least one such subtype designation, and most constraints in fact have more than one. A list of all subtypes contained in our catalog is provided in the following chart:
Table 3: Exhaustive list of constraint subtypes occurring in our spreadsheet, displayed in decreasing order of frequency

<table>
<thead>
<tr>
<th>subtype</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>featural</td>
<td>915</td>
</tr>
<tr>
<td>prosodic</td>
<td>770</td>
</tr>
<tr>
<td>phonotactic</td>
<td>766</td>
</tr>
<tr>
<td>segmental</td>
<td>661</td>
</tr>
<tr>
<td>morphological</td>
<td>348</td>
</tr>
<tr>
<td>metrical</td>
<td>249</td>
</tr>
<tr>
<td>tonal</td>
<td>102</td>
</tr>
<tr>
<td>general</td>
<td>61</td>
</tr>
<tr>
<td>autosegmental</td>
<td>57</td>
</tr>
<tr>
<td>syntactic</td>
<td>21</td>
</tr>
<tr>
<td>accentual</td>
<td>16</td>
</tr>
<tr>
<td>antialignment</td>
<td>3</td>
</tr>
<tr>
<td>phonetic</td>
<td>3</td>
</tr>
<tr>
<td>perceptual</td>
<td>2</td>
</tr>
<tr>
<td>antihomophony</td>
<td>1</td>
</tr>
<tr>
<td>intonational</td>
<td>1</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>3976</strong></td>
</tr>
</tbody>
</table>

When all 3976 tokens of the subtype annotations in Table 3 are divided by the total number of constraints in our inventory (1666), the average yields an overall mean of 2.4 subtype designations for each constraint. When a particular cell in column D contains more than one subtype, these are concatenated with a diagonal slash between them, without spaces, and in decreasing order of importance and relevance; e.g., `prosodic/morphological`. It is not uncommon in our catalog for a specific constraint to be described with four or even five subtypes. For example, constraint #1219, defined as “a syllable has crisp edges with respect to any occurrence of [Round] that it dominates,” is annotated as `autosegmental/prosodic/featural/phonotactic`. The linear order in which multiple subtypes have been listed in each cell was not determined in any rigorous way, but rather somewhat impressionistically. Consequently, there are undoubtedly some inconsistencies in how the subtypes for similar, related constraints have been entered in terms of left-to-right directionality.

Most of the constraint subtype labels in Table 3 are obvious and self-explanatory. We now discuss a few of them which may not be. The term `metrical` is used for constraints which make reference to stress, feet, and/or the corresponding grid representations. The label `autosegmental` indicates aspects of non-linear representation such as association lines, e.g., #638 MAXPATH[ATR]. The term `accentual` does not normally refer to stress per se but rather to pitch-accent and related notions. Finally, the label `general` is used for schema of related constraint families ranging over variable options, such as #36, Align(GrammaticalCategory,GEdge,ProsodicCategory,PEdge). In terms of numerically counting up the different types of constraints (as reported in the tables and figures throughout this paper), these 61 general constraints are tabulated only once each. That is, we have not attempted to estimate all of the different logically possible instantiations which could be theoretically generated by plugging specific arguments into these formulas. Rather, the only tokens of such
4.5 Definition (column E)

In this column we spell out the definition of each constraint. In all cases our default preference is to list the definition exactly as the source author has given it. This usually comes from the point in the article where the constraint is first presented. In some cases the author does not provide a formal definition. When that happens, we attempt to put together a definition gleaned from the corresponding discussion. In those rare and frustrating situations when a new constraint is proposed with no indication of what it means, we attempt to deduce the definition by examining a candidate in a tableau which violates it, and/or by analogy to similar, related constraints. In a few instances we note in this column a page number in the source where the constraint is discussed.

We reiterate here that, for the purposes of this project, we document unique constraints only, meaning those that have functionally distinct definitions. Consequently, we have made no attempt to keep track of all the variant formal names and paraphrased definitions of constraints proposed by different authors yet which have the same ultimate effect. Rather, we only include in our database the chronologically first reference to each constraint among our sample of sources. We include “duplicate” constraints (those having the same or a similar name) only when the later source defines the constraint in such a way that it behaves differently. In some cases this distinction may be rather subtle. For example, constraint #106 is named ALIGN(6,L,PrWd) and is defined as “the main stressed syllable coincides with the left edge of the prosodic word” (Gordon 2004). Entry #757 is named *#[\[-main\]] and is defined as “the syllable at the left end of the word has the main stress” (Hayes and Wilson 2008). At first glance these two constraints seem to do the same thing. Indeed, both would presumably be equally satisfied by a hypothetical candidate such as [tata]. However, since the first of these two constraints is expressed specifically in terms of alignment, it is intended to assess violations in a gradient fashion. The second constraint, on the other hand, is a markedness constraint and therefore probably assigns violation marks categorically. Thus, these two constraints potentially diverge in their evaluation of a less harmonic candidate such as [tatata] (two *’s vs. just one *, respectively). For this reason we decided to include both of them in our list.

4.6 Violated (column F)

In this column we give an example of a particular output candidate violating the constraint in question. Again our normal preference is to use a phonetic form actually provided by the author proposing the constraint, especially one that occurs in a tableau. In general we try to employ candidates which violate the constraints minimally (fewest number of *’s), but that is not always possible. When no example of a constraint violater is given by the source, we try to contrive one ourselves. In doing so we often use default, unmarked segments and structures such as [ta], [tan], [tá], etc. When the constraint being violated is a faithfulness constraint, we normally give both an output candidate and its correspondent input form, separated by an arrow (→), with no spaces in between, and without diagonal slashes or square brackets. For example, to exemplify a violation of constraint #551, MAX (no deletion), this column contains the following “derivation”: tax→ta. In some cases when examples of violation necessitate a detailed
diagram that cannot be easily entered into an Excel cell, we leave this column blank. These typically consist of complex autosegmental representations, metrical grids, etc. In most such instances we try, at the very least, to give a page number in the article where such a tableau can be found, or where violation of the constraint is discussed.

4.7 Comment (column G)

This column is used to annotate any further details of the constraint that are especially important or pertinent. For example, to document a previous source where the constraint was originally proposed, we list an abbreviated reference to that work here as Author Year. Such an entry normally refers to a book, a thesis, a dissertation, an unpublished paper, or a journal other than the four we surveyed. All such references are also listed in our bibliography at the end of this file.

To indicate that the constraint in question refers primarily to one specific language, we list that language in this column. Other common uses of this field are to note a particular framework or theoretical assumption of the author, such as BR (base-reduplicant) faithfulness, OO (output-output) faithfulness, sympathy theory, positional faithfulness, comparative markedness, etc. We also include here cases where the constraint is part of a larger family of related constraints, such as the universally fixed (impermutable) rankings characterizing the sonority hierarchy. Other annotations give further details about how the constraint is defined, how its violations are assessed, other constraints it may be similar to, etc. We also use this column to indicate more specific applications of constraints such as in loanwords, blends, hypocoristics, cophonologies, etc.

4.8 Author(s) (column H)

In this column we list the surname of the author who first proposed the constraint (within our sample). If there are two co-authors, both names are provided, separated by the ampersand symbol (&). If there are three or more co-authors we give the surname of the author listed first in the published source, followed by et al. In such cases the corresponding bibliography items at the end of this file give full details (first and last names) of all co-authors. A few cells in this column contain the surnames of two different authors, separated by a diagonal slash (/). This indicates that both authors proposed the same constraint, with the same name and definition, in the same year, but in two different works. For example, column H of constraint #1460, OCP-COR[ason], contains the entry Anttila/Coetzee & Pater. This means that this constraint was introduced by Anttila in one article, and by Coetzee and Pater in a different article, in two separate papers published in the same calendar year (2008). We do this so as not to have to determine which article actually appeared in print first.

4.9 Year (column I)

This column indicates the year in which the constraint in question first appears among our sources. For more than one article written by the same author in the same year, we append a lower case letter (a, b, c, etc.) to the end of the year. These correspond to the order in which the respective entries occur in our alphabetized bibliography list at the end of this document.
4.10 Journal (column J)

This column notes the journal in which each constraint was originally proposed (by the author in column H and in the year in column I). The names of the journals in our spreadsheet are abbreviated as follows (cf. (2)):

(5) Journal abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phono</td>
<td>Phonology</td>
</tr>
<tr>
<td>LI</td>
<td>Linguistic Inquiry</td>
</tr>
<tr>
<td>NLLT</td>
<td>Natural Language &amp; Linguistic Theory</td>
</tr>
<tr>
<td>Lang</td>
<td>Language</td>
</tr>
</tbody>
</table>

If the source of a new constraint is one of the other four major works listed in (3), we leave this column blank. In those cases when a constraint appears twice in the same year (but in two different articles), we give the names of both journals in this column, separated by a diagonal slash. The two journal names are listed in the same left-to-right order as the two corresponding authors in column H (see §4.8). For example, constraint #921, *DORSAL, has the names Smolensky/Golston in the author(s) column, 1996 in the year column, and LI/Lang in the journal column. This means that this constraint was first proposed in 1996 by Smolensky in a paper in Linguistic Inquiry, as well as by Golston in a paper in Language, also in 1996.

4.11 Number (column K)

Finally, this column contains a fixed, unique number for each constraint, to serve as a persistent identifier for that entry. For example, when the database is sorted in different ways, individual constraints can still be referred to using this numbering system. Furthermore, in order to return the catalog to its current, default state (see §4.12), all the user has to do is sort the entire spreadsheet by this column, in ascending order. Similarly, sorting this column in descending order has the effect of reversing the entire constraint list, etc. This column is placed last in row 1 of the Excel file since it will often be the least important detail of each constraint to keep in mind. Thus on a normal sized computer screen it will tend to protrude off to the right, beyond the viewing area of the pane. This allows the user to focus on the other, more important fields appearing earlier (farther to the left) in the database.

4.12 Sorting order

As noted in §4.3, the default order in which the 1666 constraints are currently listed in our database has been sorted first by type (column C), then by name (column A), and finally by year (column I). All of these are in ascending alphabetical order (or numerical for the year), using the default parameters built into Excel. Thus the year in which a constraint was first proposed is crucial (with respect to the order of constraints in our spreadsheet) only when there are two or more constraints of the same type and with the same name, but with functionally different definitions. For example, Ussishkin proposed OCP-Place in 1999, and Frisch et al. proposed a constraint with the same name but a slightly distinct definition in 2004. Consequently, the 1999 version of this constraint appears first in our catalog (#1475), and the
2004 counterpart appears right after it (#1476). One advantage of presenting our constraint inventory in an Excel spreadsheet is that it allows the user to reorder the entire list simultaneously using a number of fast and customizable search options. Conversely, a fixed table in a Word document would not have provided the same amount of flexibility.

5. Statistical analysis and discussion

In this section of the paper we further develop the results previewed in §2. First we consider the relative proportions of the distinct constraints by type. Then we discuss the distribution of all the constraints among the four major journals. Finally, we make a few observations about the numbers of newly-proposed constraints per year.

5.1 Constraints divided by type

As already stated, a total of 1666 unique constraints are documented in our database. Their distribution according to type is displayed in the table below. This is a copy of Table 1, supplemented with relative percentages:

<table>
<thead>
<tr>
<th>constraint type</th>
<th>number</th>
<th>percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>markedness</td>
<td>902</td>
<td>54.1%</td>
</tr>
<tr>
<td>faithfulness</td>
<td>492</td>
<td>29.5%</td>
</tr>
<tr>
<td>alignment</td>
<td>241</td>
<td>14.5%</td>
</tr>
<tr>
<td>local conjunction</td>
<td>11</td>
<td>.7%</td>
</tr>
<tr>
<td>other/miscellaneous</td>
<td>11</td>
<td>.7%</td>
</tr>
<tr>
<td>antifaithfulness</td>
<td>9</td>
<td>.5%</td>
</tr>
<tr>
<td>total</td>
<td>1666</td>
<td>100%</td>
</tr>
</tbody>
</table>

As Table 4 indicates, markedness constraints are more frequent in our sample (54.1%) than the remaining five categories of constraints combined. With a sample size this large, a skew in distribution of this magnitude is obviously going to be astronomically significant from a statistical point of view: \( \chi^2(5) = 2346.3 \). The preponderance of markedness constraints is nicely illustrated in the following pie chart. For some reason Excel rounds its percentage value to 53% rather than 54%. We presume this is because local conjunction, other/miscellaneous, and antifaithfulness are each rounded up to 1%, and the total of all six categories must add up to 100%:
As Figure 1 graphically shows, the three most common types (markedness, faithfulness, and alignment) together account for about 97% of all constraints. The remaining three categories (local conjunction, antifaitfulness, and other/miscellaneous) are clearly of marginal weight (frequency) in our inventory overall. Recall from §4.3 that we consciously chose to classify a constraint as markedness ($m$) rather than other ($o$) whenever possible. This is obviously part of the explanation for why markedness constraints are so predominant. However, it cannot be the full story since there are just not very many ambiguous constraints which could have gone either way. Of the 902 total constraints we have classified as markedness, we estimate that fewer than 100 would be in question if someone wishes to dispute our categorization. Consequently, the fact that markedness “wins”, and by such a large degree, is not in doubt.

Even the distinction between markedness and faithfulness constraints is sometimes also debatable. In three such cases we contacted the original authors to get their input. For example, Rose and Walker (2004) propose a family of IDENT-CC(feature) constraints. Building on the analogy with the name IDENT(feature), Rachel Walker (p.c.) considers these to be a kind of output-output faithfulness constraint. Hansson (2007) proposes a related type of constraint which has a very similar name, definition, and function, citing Rose and Walker (2004). Nevertheless, when we contacted him, Gunnar Hansson (p.c.) interpreted his constraints to be a kind of long-distance agreement by spreading, and therefore markedness in nature. In the final analysis we chose to side with Walker, somewhat arbitrarily. Since there are only 14 constraints of this kind among our sample, the overall outcome would not be affected significantly either way.

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2Thanks to Rachel Walker and Gunnar Hansson for discussion of this issue. We also received personal input from Outi Bat-El about a different kind of constraint.
5.2 Constraints divided by journal

In this section we return to the issue of which journal publishes the most new constraints overall. As noted in Table 2, *Phonology* is the most prolific among our sample, while *Language* is the least of these four. The following table repeats this breakdown, including relative percentages, in decreasing order of frequency:

Table 5: Overall numbers of newly-proposed constraints distinguished by journal, with percentages

<table>
<thead>
<tr>
<th>journal</th>
<th>number of constraints</th>
<th>percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phonology</td>
<td>558</td>
<td>36%</td>
</tr>
<tr>
<td>Linguistic Inquiry</td>
<td>371</td>
<td>24%</td>
</tr>
<tr>
<td>Natural Language &amp; Linguistic Theory</td>
<td>340</td>
<td>22%</td>
</tr>
<tr>
<td>Language</td>
<td>261</td>
<td>17%</td>
</tr>
<tr>
<td>total</td>
<td>1530</td>
<td>100%</td>
</tr>
</tbody>
</table>

In Table 5 the combined number of constraints (1530) is less than the overall total of 1666 contained in our database (Tables 1 and 4). This is because we are focusing here only on the journal venue. This implies that the remaining number of unique constraints comes from the four other seminal OT works which we also surveyed (see (3) and the Appendix). The following histogram depicts the proportion of constraints ascribable to each journal:

Figure 2: Relative percentages of constraints distinguished by journal, from Table 5
In order to help interpret Figure 2, we calculated chi-square tests on the numbers of constraints by journals from Table 5. These confirm that there are some reliable differences among our obtained values:

Table 6: Results of $\chi^2$ tests on the numbers in Table 5

<table>
<thead>
<tr>
<th>comparison</th>
<th>$\chi^2$</th>
<th>df</th>
<th>$p$</th>
<th>significant?</th>
</tr>
</thead>
<tbody>
<tr>
<td>all four journals simultaneously</td>
<td>124.2</td>
<td>3</td>
<td>.0000</td>
<td>yes</td>
</tr>
<tr>
<td>Phonology vs. LI</td>
<td>37.6</td>
<td>1</td>
<td>.0000</td>
<td>yes</td>
</tr>
<tr>
<td>LI vs. NLLT</td>
<td>1.4</td>
<td>1</td>
<td>.2449</td>
<td>no</td>
</tr>
<tr>
<td>NLLT vs. Language</td>
<td>10.4</td>
<td>1</td>
<td>.0013</td>
<td>yes</td>
</tr>
</tbody>
</table>

df = degrees of freedom

As the results in Table 6 demonstrate, a four-way comparison of all journals simultaneously is significantly different from chance. This is expected, but it does not directly tell us where in the distribution this asymmetry comes from. For this reason we also performed chi-square calculations on each pair of journals which are adjacent to each other in Table 5 and Figure 2. For example, in Table 6 we observe that Phonology publishes more new constraints overall than LI, to a degree that is statistically significant. By transitivity we may assume that the value for Phonology is also greater than those of NLLT and Language. This is not surprising (§2) since, of these four journals, Phonology is the only one devoted exclusively to the field it is named for. Furthermore, it is somewhat expected that Language would exhibit the fewest number of new constraints since it is a more eclectic journal than the other three. By this we mean that Language is less oriented in general to formal theories such as OT. Thus, the difference in constraint numbers between NLLT and Language is reliably distinct. However, the difference between LI and NLLT is not. We therefore conclude that, in terms of the quantities of new constraints uncovered by our sampling methodology, LI has not published a significantly greater number than NLLT.

5.3 Constraints divided by year

In this section we consider the relative numbers of new constraints published each year for which we sampled the four journals (see §5.2). The corresponding breakdown for the four other foundational OT works in (3) is given in the Appendix. As noted previously, articles about OT first appeared in the journals in 1995 (§2). Furthermore, the cut off date for finishing our sample goes through calendar year 2008 (§3). The following table displays the numbers of constraints proposed across this range of dates:
Table 7: Overall numbers of newly-proposed constraints among the four journals combined, distinguished by year of publication

<table>
<thead>
<tr>
<th>year</th>
<th>number of constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>34</td>
</tr>
<tr>
<td>1996</td>
<td>106</td>
</tr>
<tr>
<td>1997</td>
<td>136</td>
</tr>
<tr>
<td>1998</td>
<td>78</td>
</tr>
<tr>
<td>1999</td>
<td>90</td>
</tr>
<tr>
<td>2000</td>
<td>165</td>
</tr>
<tr>
<td>2001</td>
<td>100</td>
</tr>
<tr>
<td>2002</td>
<td>83</td>
</tr>
<tr>
<td>2003</td>
<td>78</td>
</tr>
<tr>
<td>2004</td>
<td>88</td>
</tr>
<tr>
<td>2005</td>
<td>87</td>
</tr>
<tr>
<td>2006</td>
<td>165</td>
</tr>
<tr>
<td>2007</td>
<td>111</td>
</tr>
<tr>
<td>2008</td>
<td>209</td>
</tr>
<tr>
<td>total</td>
<td>1530</td>
</tr>
</tbody>
</table>

Once again, the total number of constraints in Table 7 (1530) is less than the overall sum contained in our inventory (1666). This is because we are focusing only on the four journals in this section (cf. §5.2). The following scatterplot shows that the general trend across years gradually rises upwards (see §2):
In Figure 3 the jagged red line directly connects each data point with its successor. The thicker blue line running horizontally through the entire window represents the corresponding linear regression equation. This is the formula which best fits the distribution of data points using the least-squares method. As this diagram shows, the slope of the regression line runs in a mildly positive direction, at an overall average rate of about 30% per year (§2). From this fact we conclude that OT has not yet reached a point of saturation. That is, at the moment there is no evidence that the amount of cutting-edge work on OT has begun to decline. At the very least this inference is suggested by the numbers of new constraints still emerging annually. However, given the typical lag time for publishing in these journals, perhaps it would be more accurate to say that OT was not yet declining as of 2006 or so.3

6. Previous constraint inventories

Several previous researchers have also compiled lists of OT constraints. In this section we briefly review a few of these works and compare them with our own database. The bottom line is that none of these other inventories comes close to ours in terms of two important criteria: (1) completeness, and (2) potential for searchability.

A number of textbooks and other standard OT references contain summary lists of constraints. Examples include Kager (1999), McCarthy (2002), and McCarthy (2008a). Most of these sources, however, limit their lists to just those constraints actually used and discussed in those books. To illustrate, the mean number of constraints appearing in the indices at the back of

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3Thanks to Paul de Lacy (p.c.) for pointing this out.
each of the three references above is 122. In some cases such works also provide more focused
sublists. For example, McCarthy (2008a:223-29) offers the reader a “classified list of common
phonological markedness constraints” involving 55 constraints, including brief notes, definitions,
and references. We have also encountered one journal article which does something similar:
Hargus and Beavert (2006:51-54) present a list of 34 constraints which “refer to consonants
and/or vowels.” All of these are no doubt helpful and useful, albeit limited in scope (by design).

We are also aware of one electronic repository of OT constraints: Constraint Catalogue
(ConCat). This is a public wiki conceived of by Curt Rice and Marc van Oostendorp in 2006. In
2009 a few hundred constraints were entered by Anna Fragkiadaki and Sofia Kousi, students at
Meertens Institute. Each entry includes a constraint name, definition, references, links to related
constraints, and an indication of how its violations are assessed. This is obviously a very
important resource that should benefit any serious researcher interested in OT.

In contrast to all of these works, however, our database offers a much more exhaustive
inventory of constraints. These have been selected using a number of rigorous and principled
criteria (§3). Furthermore, the fact that they appear all together in a single Excel spreadsheet
allows for very rapid, efficient, and powerful searching on demand. Consequently, we conclude
that our project is arguably the best constraint catalog of its kind which currently exists.

7. Conclusion

For those linguists who are concerned about the total number of OT constraints ever
proposed, our final figure of 1666 constraints is probably disheartening. However, to maintain a
bit of perspective, it is important to keep in mind that the ultimate test for evaluating a linguistic
model is not what it looks like on paper on how much ink it takes to write up its formalisms.
Rather, the ultimate test to evaluate a linguistic theory is what you can and cannot do with it. The
factorial typology of different languages which can be generated by all 1666! permutations of
this constraint set is undeniably staggering, and likely impossible to even compute in practical
terms. Nevertheless, a large number of these grammars are formally indistinct since many
constraints do not directly conflict with each other. Furthermore, many constraints form part of
subhierarchies characterized by fixed internal rankings. Also, as we highlighted in §1, not all of
these constraints can co-exist in CON simultaneously, i.e., many of them are theoretically
incompatible with each other. Therefore, the final number of constraints is undoubtedly less than
1666. At the same time, however, we have not included here any of the new constraints proposed
since 2008, so we are in no position at this time to speculate about how high or low this total will
ultimately go.

Perhaps the most crucial issue facing this collection of constraints is that of learnability:
even with ±1666 constraints, is the human computational apparatus capable of learning specific
grammars, i.e., rankings plus lexical items? In this respect what ultimately matters is not the
number of constraints per se, but rather the ability of the learner to reach an appropriate
language-specific ranking of them. We leave this question — the viability of the acquisition
process — as a topic for future research.

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4The main page is found at the following URL: http://concat.wiki.xs4all.nl/index.php?title=Main_Page.
Acknowledgements

We are grateful to Paul de Lacy, John McCarthy, and Shigeto Kawahara for helpful suggestions about this project. Please do not assume that any of them necessarily agree with anything we have stated here. The names of the co-authors are listed in alphabetical order. For feedback and discussion please write to steve_parker@gial.edu.

Appendix: Complete list of numbers of newly-proposed constraints
broken down by type, year of publication, and source

This table is referred to at various points in the body of the paper (§2, 3, 5.2, and 5.3). The sum of all the values here is greater than the total number of constraints in our database (1666; see Tables 1 and 4). This is because some constraints were proposed by more than one author in the same year (cf. §4.8 and 4.10). Hence there are a few duplications in this table.

| year → | M  | F  | A  | LC | O/M | AF  | ←source
|--------|----|----|----|----|-----|-----|-----------------
| 1993   | 29 | 6  | 5  |    |     |     | Prince & Smolensky
| 1993   | 1  | 16 |    |    |     |     | McCarthy & Prince a
| 1993   | 16 | 5  | 12 |    |     |     | McCarthy & Prince b
| 1995   | 24 | 39 | 1  |    |     |     | McCarthy & Prince
| 1995   | 7  | 4  | 5  |    |     |     | Phono
|        | 11 | 4  | 3  |    |     |     | LI
|        |    |    |    |    |     |     | NLLT
|        |    |    |    |    |     |     | Lang
| 1996   | 17 | 12 | 2  |    |     |     | Phono
|        | 9  | 9  | 3  |    |     |     | LI
|        |    |    |    |    |     |     | NLLT
|        |    |    |    |    |     |     | Lang
| 1997   | 40 | 11 | 20 |    |     |     | Phono
|        | 4  | 4  | 3  | 1  |     |     | LI
|        | 10 | 17 | 3  |    |     |     | NLLT
|        | 17 | 6  |    |    |     |     | Lang
| 1998   | 11 | 10 | 1  |    |     |     | Phono
|        | 4  | 5  | 7  |    |     |     | LI
|        | 16 | 7  | 17 |    |     |     | NLLT
|        |    |    |    |    |     |     | Lang
| 1999   | 18 | 9  | 9  | 2  |     |     | Phono
|        | 8  | 12 | 6  |    |     |     | LI
|        | 15 | 1  | 4  |    |     |     | NLLT
|        | 4  | 2  |    |    |     |     | Lang
| 1998   | 11 | 10 | 1  |    |     |     | Phono
|        | 4  | 5  | 7  |    |     |     | LI
|        | 16 | 7  | 17 |    |     |     | NLLT
|        |    |    |    |    |     |     | Lang
| 1999   | 18 | 9  | 9  | 2  |     |     | Phono
|        | 8  | 12 | 6  |    |     |     | LI
|        | 15 | 1  | 4  |    |     |     | NLLT
|        | 4  | 2  |    |    |     |     | Lang

Page 220 of 281
<table>
<thead>
<tr>
<th>Year</th>
<th>Page 1</th>
<th>Page 2</th>
<th>Page 3</th>
<th>Page 4</th>
<th>Journal</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>49</td>
<td>40</td>
<td>12</td>
<td>3</td>
<td>Phono</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>13</td>
<td>1</td>
<td></td>
<td>LI</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>8</td>
<td>3</td>
<td></td>
<td>NLLT</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>6</td>
<td>1</td>
<td></td>
<td>Lang</td>
</tr>
<tr>
<td>2001</td>
<td>5</td>
<td>9</td>
<td>2</td>
<td>7</td>
<td>Phono</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>10</td>
<td></td>
<td></td>
<td>LI</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>12</td>
<td>3</td>
<td></td>
<td>NLLT</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>2</td>
<td></td>
<td></td>
<td>Lang</td>
</tr>
<tr>
<td>2002</td>
<td>20</td>
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<td>8</td>
<td>1</td>
<td>Phono</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>1</td>
<td></td>
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<td>LI</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>4</td>
<td>8</td>
<td></td>
<td>NLLT</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>4</td>
<td>1</td>
<td></td>
<td>Lang</td>
</tr>
<tr>
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<td>4</td>
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<td>9</td>
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</tr>
<tr>
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<td>8</td>
<td>4</td>
<td></td>
<td>LI</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>NLLT</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>10</td>
<td></td>
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<tr>
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<td></td>
<td>10</td>
<td>6</td>
<td></td>
<td></td>
<td>Lang</td>
</tr>
</tbody>
</table>

Legend of constraint types (cf. (4)):  
- M = markedness  
- F = faithfulness  
- A = alignment  
- LC = local conjunction  
- O/M = other/miscellaneous  
- AF = antifaithfulness

Legend of journals (cf. Table 2 and (5)):  
- Phono = Phonology  
- LI = Linguistic Inquiry  
- NLLT = Natural Language & Linguistic Theory  
- Lang = Language
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Local Conjunction (or, the gods just might be crazy)

The basic idea behind local conjunction (LC) of constraints is to penalize the “worst of the worst” type of behavior (Smolensky 1995).

For example, if codas are bad in general, and voiced obstruents are also universally marked, then codas consisting of voiced obstruents are especially dispreferred.

Constraints like NOCODA and *VOICEDOBSTRUENT are already strongly motivated as independent markedness statements. So instead of positing a completely new, brute force constraint like the hypothetical *VOICEDCODA, we combine the two more basic and elementary constraints into a combination which can be ranked independently from them: [NOCODA & *VOICEDOBSTRUENT]_segment. In this case the subcategorization segment specifies the domain of scansion for this locally-conjoined constraint.

(1)

<table>
<thead>
<tr>
<th></th>
<th>NOCODA</th>
<th>*VOICEDOBSTRUENT</th>
<th>[NOCODA &amp; *VOICEDOBSTRUENT]_seg</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>[beyt]</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b.</td>
<td>[beyd]</td>
<td>*</td>
<td>**</td>
</tr>
<tr>
<td>c.</td>
<td>[peyt]</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>[peyd]</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>[pey]</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

It has been claimed that there is a universal ranking scheme governing LC (much like the stringency relationship between positional faithfulness constraints and general faith):

(2) \[ [C_1 \& C_2]_\delta \] \[\Rightarrow\] C_1, C_2

A major concern, however, is that LC subverts the “strictest of strict” domination principle of standard OT, by which no amount of violations of a lower ranked constraint can “gang up” to overcome a higher ranked constraint. This scenario would in fact take place in a ranking subhierarchy of the following nature:

(3) \[ [C_2 \& C_3]_\delta \] \[\Rightarrow\] C_1 \[\Rightarrow\] C_2, C_3
A number of troubling questions have arisen concerning the power of LC. These fall into two main issues: universality, and learnability. To date they have not yet been answered in a fully satisfying way.

For example,

(a) What types of constraints can be conjoined: markedness with markedness only? What about faithfulness with faithfulness? Or what about M plus F?

(b) How many constraints can be combined at the same time? Only two? If so, why? Or more than two? What is the upper limit on constraint conjunction, and on what principled basis do we draw the line where we do?

(c) Are conjoined constraints universal in the sense that they are given along with CON? That is, are conjoined constraints part of a human being’s genetic endowment such that all needed combinations are already present at birth? Or does each child need to learn those combinations of constraints which are required only in his or her language? If so, how is this done?

(d) Once we allow that some constraints are joined together, does this mean that every constraint in CON is conjoined with every other one? If so, the proliferation of possible grammars grows exponentially. If not, where do we stop the process, and how do we know to do this?

All of these issues call for explicit empirical answers, and until they are fully fleshed out in the OT literature, they should make us worry about the potential abuse of LC. At the very least, it seems safe to assert that LC is a complication in the sense that analyses which crucially rely on it need an additional type of formal mechanism compared with those which avoid LC.

One potentially very good usage of LC is to deal with situations of synchronic chain shift. For example, there is a dialect of Spanish spoken in northwestern Spain in which /a/ is mapped to [e] and /e/ is mapped to [i] in the same environment (McCarty 2002): 

(4)

(a) /gat + a/ → [gata] ‘cat (feminine)’
/gat + u/ → [getu] ‘cat (masculine)’
/blank + a/ → [blanka] ‘white (feminine)’
/blank + u/ → [blenku] ‘white (masculine)’
The generalization is that a stressed root vowel raises one step when the suffixal vowel is high.

Assume a generic markedness constraint (M): a vowel must be high when the following syllable contains a high vowel.

(The original analysis along these lines is due to Kirchner 1996.)
Rendaku and Lyman’s Law in Japanese

1. iro + kami → irogami
   ‘color’ ‘paper’ ‘colored paper’

2. asa + kiri → asagiri
   ‘morning’ ‘mist’ ‘morning mist’

3. de + kuči → deguči
   ‘leave’ ‘mouth’ ‘exit’

4. eda + ke → edage
   ‘branch’ ‘hair’ ‘split hair’

5. unari + koe → unarigoe
   ‘moan’ ‘voice’ ‘groan’

6. yo + sakura → yozakura
   ‘night’ ‘cherry’ ‘blossoms at night’

7. inu + šini → inužini
   ‘dog’ ‘death’ ‘useless death’

8. maki + suši → makizuši
   ‘rolled’ ‘sushi’ ‘rolled sushi’

9. mizu + seme → mizuzeme
   ‘water’ ‘torture’ ‘water torture’

10. hoši + sora → hošizora
    ‘star’ ‘sky’ ‘starry sky’

11. e + tako → edako
    ‘picture’ ‘kite’ ‘picture kite’

12. yama + tera → yamadera
    ‘mountain’ ‘temple’ ‘mountain temple’

13. yu + toofu → yudoofu
    ‘hot water’ ‘tofu’ ‘boiled tofu’
<table>
<thead>
<tr>
<th></th>
<th>Characters</th>
<th>Meaning 1</th>
<th>Meaning 2</th>
<th>Meaning 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.</td>
<td>hana + či</td>
<td>'nose’</td>
<td>‘blood’</td>
<td>hanači</td>
</tr>
<tr>
<td>15.</td>
<td>kokoro + t'ukai</td>
<td>'heart’</td>
<td>‘usage’</td>
<td>kokoročukai</td>
</tr>
<tr>
<td>16.</td>
<td>kami + kaze</td>
<td>'wind’</td>
<td>kamikaze (*kamigaze)</td>
<td>‘divine wind’</td>
</tr>
<tr>
<td>17.</td>
<td>mono + šizuka</td>
<td>‘tranquil’</td>
<td>monošizuka (*monožizuka)</td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>širo + tabi</td>
<td>‘white tabi’</td>
<td>širotabi (*širodabi)</td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>oharai + kuši</td>
<td>‘purification’</td>
<td>‘comb’</td>
<td>oharaišuši</td>
</tr>
<tr>
<td>20.</td>
<td>oharai + kuji</td>
<td>‘ticket’</td>
<td>oharaičuki (*oharaiguši)</td>
<td>‘purification ticket’</td>
</tr>
<tr>
<td>22.</td>
<td>onna + kokoro</td>
<td>‘woman’</td>
<td>‘heart’</td>
<td>onnagokoro</td>
</tr>
<tr>
<td>23.</td>
<td>onna + kotoba</td>
<td>‘woman’</td>
<td>‘word’</td>
<td>onnakotoba (*onnagotoba)</td>
</tr>
<tr>
<td>24.</td>
<td>mizu + teppoo</td>
<td>‘water’</td>
<td>mizudeppoo</td>
<td>‘water pistol’</td>
</tr>
<tr>
<td>25.</td>
<td>ore + kugi</td>
<td>‘broken nail’</td>
<td>orekugi (*oregugi)</td>
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</tr>
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Sources of data:


<table>
<thead>
<tr>
<th>group 1 (changes)</th>
<th>group 2 (doesn’t change)</th>
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<tr>
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<td>ŝizuka</td>
</tr>
<tr>
<td>kuči</td>
<td>tabi</td>
</tr>
<tr>
<td>ke</td>
<td>kuji</td>
</tr>
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<td>koe</td>
<td>ŝinogi</td>
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<td>sakura</td>
<td>kotoba</td>
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<td>kugi</td>
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<tr>
<td>suši</td>
<td></td>
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<tr>
<td>seme</td>
<td></td>
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<tr>
<td>sora</td>
<td></td>
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<tr>
<td>tako</td>
<td></td>
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<tr>
<td>tera</td>
<td></td>
</tr>
<tr>
<td>toofu</td>
<td></td>
</tr>
<tr>
<td>či</td>
<td></td>
</tr>
<tr>
<td>t’ukai</td>
<td></td>
</tr>
<tr>
<td>kuši</td>
<td></td>
</tr>
<tr>
<td>kokoro</td>
<td></td>
</tr>
<tr>
<td>teppoo</td>
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</tbody>
</table>
Observation: in serial derivations, rules express temporary generalizations. Opacity is a potential difficulty for OT since it leads to situations in which constraints do not hold true of surface forms.

Definition of opacity (after Kiparsky 1973):

A phonological rule \( P \) of the form \( A \rightarrow B / C \_\_\_ D \) is **opaque** if there are surface structures with either of the following characteristics:

a. instances of \( A \) in the environment \( C \_\_\_ D \).

b. instances of \( B \) derived by \( P \) that occur in environments other than \( C \_\_\_ D \).

Situation (a) will occur as a result of a counterfeeding interaction between rule \( P \) and another rule that follows \( P \) and produces instances of the string \( CAD \).

Situation (b) will occur as a result of a counterbleeding interaction between rule \( P \) and another rule that follows \( P \) and modifies either \( C \) and/or \( D \).

Both of these two different types of opacity are problematic for OT because they lead to a situation in which some constraint which generally holds true of surface forms appears to have exceptions: optimal candidates which look like they should have undergone a process, but didn’t.

In other words, opacity is a situation in which it **looks like** a rule should have applied to a certain form but didn’t, or a rule shouldn’t have applied to a certain form but it did.

Opacity represents perhaps the most difficult challenge to a fully parallel model of OT (McCarthy 2002).

There are three main ways in which opacity has been dealt with in OT:

1. local conjunction
2. derivational or stratal approaches
3. output-output faithfulness

In a derivational or stratal model of OT, evaluation of the candidate set output by GEN is not strictly parallel (once and for all, all at the same time). Rather, evaluation takes place in two or more steps (serialism). Each step in this process corresponds to a different level or stratum. This mimics the derivational nature of earlier rule-based approaches, such as Lexical Phonology. All the forms output by one stratum then serve as inputs to the next stratum. Because of this,
Richness of the Base holds only for the initial level. The main difficulty for stratal OT is to attempt to motivate each level (stage) of the grammar with independent evidence, such as a confluence of several different phonological processes that must all take place in one block.

The third approach for dealing with opacity in OT is by appealing to paradigm uniformity, where a certain morpheme remains constant across different inflectional and/or derivational categories. This is called uniform exponence. The first and strongest proponent of this line of attack is Benua (1995, 1997). Her proposal is known as Output-Output Correspondence or Output-Output Faithfulness (OO-FAITH). The key idea of this approach is that, in addition to Input-Output faithfulness constraints (IO-FAITH), CON should be expanded such that derived forms must also be faithful to one or more aspects of the morphological base form. It thus supplements our inventory of constraints with a new family of OO faithfulness constraints requiring identity with a morphologically more simple form. In this way it can capture what are known as paradigm uniformity effects. The main problem for OO-FAITH is trying to define what constitutes the base form of a paradigm in an a priori and principled fashion that holds true for all languages.

To illustrate this approach, consider the contrast between the words *capitalistic* and *militaristic*. In *capitalistic* the first /t/ is normally flapped, whereas in an analogous environment in *militaristic*, the first /t/ cannot be flapped. The explanation for this difference resides in the corresponding unsuffixed roots *capital* vs. *military*. In *capital* the vowel after the /t/ is unstressed, so flapping applies. In *military*, however, the vowel right after the /t/ bears secondary stress, so flapping is blocked. This is a case of counterfeeding opacity since the addition of a suffix to *military* leads to an environment in which flapping is expected to apply, but it doesn’t.

We thus invoke an OO faithfulness constraint requiring that a /t/ in a derived word be featurally unchanged with respect to its correspondent in the base (unaffixed root). A potential difficulty (challenge) for this approach is to give a precise and universal definition of what constitutes a base.

Summary of the basic facts:

*capital*, with a flap derived from underlying /t/, conditioned by metrical structure (stress).

Cf. *capitalistic*.

*military*, with no flapping in a stressed syllable.

Cf. *militaristic*, with no flapping in an environment contrasting minimally with that of *capital*.

\[
\text{(4) FLAPPING (Markedness) } \Rightarrow \text{ IDENT-IO (Faithfulness between the Input and the Output)}
\]

\[
\begin{array}{|c|c|c|}
\hline
\text{Input: capital} & \text{FLAPPING} & \text{IDENT-IO} \\
\hline
\text{a. capi[t]al} & *! & \\
\hline
\text{b. capi[D]al} & * & \\
\hline
\end{array}
\]
A reflection by McCarthy (2002:176) on OO-Faith: “an opaque interaction is possible whenever a transparent process in a morphologically simplex form is carried over to a morphologically derived form.... [T]he principal question needing investigation is whether all observed opaque interactions involve the right kind of morphological conditions to allow this kind of analysis to go through.”

References


A common, obvious idea is to combine OT with Lexical Phonology. Assume a series of different (=differently ranked) OT grammars that are serially linked and which correspond to the different levels of LP. The output of one level is the input to the next level (and hence the potential object of faithfulness constraints).

One particular implementation, due to Kiparsky 1997:

- Three levels: cyclic (stem), word, and postlexical.
- Each level is a constraint system that evaluates candidates in parallel.
- The output of one derivation is the input to the next derivation.
- Each level assigns its outputs to prosodic categories such as the Prosodic Word.
- Apparent cyclic effects in derived words result from faithfulness to the base.
- The levels differ only in the ranking of faithfulness constraints (like OO-Faith).
- “Faithfulness constraints can outrank prosodic constraints, but the constraint system at each level evaluates fully-realized output representations in parallel.”
- An important claim: “[A]doption of this serial regime permits elimination of a type of alignment constraint and of OO, BR, and Sympathy.”

Some remarks:

- The claim that OT/LP can eliminate the need for OO-Faith is expected, since they’re basically theories of the same sort of thing.
- It’s slightly less expected to see the claim that OT/LP can eliminate the need for (MCat, PCat) alignment; this is presumably the reason why the implementation heavily relies on various aspects of prosodic structure.
- The claim that OT/LP can eliminate the need for sympathy constraints is tantamount to the claim that all opacity is reducible to between-level or cyclic ordering effects. This is quite surprising and novel.

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“The proposed analysis of glottal stop and glide insertion has shown that Optimality Theory needs to be modified to permit derivationalism, albeit on a limited scale. The modified framework, which I call Derivational Optimality Theory (DOT), is governed by the three principles in (66), all of which stem from the general philosophy of Occam’s razor.
(66)  

a.  *Level Minimalism*  
The number of derivational levels is minimal.

b.  *Reranking Minimalism*  
The number of rerankings is minimal.

c.  *Constraint Minimalism*  
The number of constraints is minimal.

Of these three principles, Reranking Minimalism carries the clearest message: reranking of constraints comes at a cost and needs to be argued for. Level Minimalism assigns cost to postulating intermediate levels. There is one exception, though: word level and postlexical (sentence) level should be regarded as available at no cost. These two levels are robustly substantiated by the languages considered in this article, which is not surprising because word phonology and sentence phonology have been viewed as distinct from time immemorial. I conclude that the word level and the sentence level are an integral part of the DOT model but additional levels require motivation” (p. 313).

Slovak:

[holub]        ‘pigeon’
[holúb-æ]      ‘pigeon (diminutive)’
[pán]          ‘master’

/pán-æ/ → [páña]  ‘master (diminutive)’ This form is opaque because the /n/ has palatalized even though the underlying front vowel /æ/ which triggers this process has independently been backed.

æ-BACKING: No [æ] after nonlabials.

Level 1: /n+æ/

<table>
<thead>
<tr>
<th>Input: /n+æ/</th>
<th>PALATALIZATION</th>
<th>IDENT([-back])</th>
<th>æ-BACKING</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ⁸⁸ fnæ</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b.  næ</td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c.  na</td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>d.  ña</td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

Level 2:

<table>
<thead>
<tr>
<th>Input: /ñ+æ/</th>
<th>PALATALIZATION</th>
<th>æ-BACKING</th>
<th>IDENT([-back])</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ⁸⁸ ña</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b.  ñæ</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.  na</td>
<td></td>
<td></td>
<td>**!</td>
</tr>
<tr>
<td>d.  næ</td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>
strengths:

- He presents a fair amount of good, systematic data, so his arguments are not based on just a few unproductive forms.
- The three derivational levels he posits are motivated by converging evidence from different processes.

potential weaknesses:

- He does not flesh out the theoretical issues/problems with derivational OT very well.
- He uses a loose definition of Duke-of-York derivations when he illustrates this as $k \rightarrow ch' \rightarrow ch$ (hard to soft to hard), where we do not end up with exactly the same segment that we started out with.
- I find his constraint (37) “Don’t be a palatalized labial” more ad hoc than some of the others. It might be better to just invoke a general prohibition against palatalization, and separate IDENT constraints for the place nodes Labial, Coronal, and Dorsal.

Some questions which did not get addressed but would have been helpful:

Which types of constraints can rerank between levels? Markedness only, or Faithfulness only, or both? Why?

The DOY processes illustrated here are all instances of feature changing. What are the implications if a segment is first deleted and then later inserted? Or vice-versa?

Are there any inherent restrictions on what kinds of processes can exemplify DOY derivations? For example, can we let two segments metathesize and then unmetathesize? What a priori principle rules this out, and why is it not attested?

Why are there so few cases of DOY derivations reported in the literature? What is the upper limit on the number of different derivational levels present in one language, and why? For example, what prevents someone from positing 37 postlexical strata? Or a mapping from A to B then to C then to D then back to A?

How much evidence is needed to justify each distinct derivational level?

Out of curiosity, how would John McCarthy respond to this paper?
Rounding Harmony in Chumburung

Keith Snider

1. Rounding Harmony

In Chumburung, with certain predictable exceptions (see below) the feature [+ROUND] spreads leftwards from the right-most round vowel or consonant (w) to the beginning of the word. See the data set immediately below.

Right-most round segment is at end of word
mu rúturu turn around
t∫ont∫urʊŋ loincloth
tɔsʊrɔ load
kɔkʊtɔ fingernail, claw
kɔntɔ snail
kʊɲʊ head
fʊ snatch

Right-most round segment is elsewhere in the word
djʊkɔrɪ bat
kɔwɔrɪ pounding
kɔlɔpɔnɪ scar
kʊnɔkwɪ testicle
kɔwɛʔ testicle
kɔsɪ scrape

1.1 Relevant constraints:

ALIGN-L [+ROUND] The feature [+ROUND] must be aligned with the left edge of the constituent.
NOGAP Multiply linked features cannot skip elements.
ID: [ROUND] The input and the output must be identical with respect to roundness.
[+ROUND]/[+BACK] If a segment is [+ROUND], it will also be [+BACK].
MAX: [+ROUND] The output must not delete a [+ROUND] feature that is on the labial tier of the input.

1.2 Ranking:

a. With respect to the ranking of these constraints, throughout the language [+ROUND]/[+BACK] is never violated. Round vowels are always back vowels. a is also a back vowel and it is not round, so the converse that all back vowels are also round is not true. So [+ROUND]/[+BACK] is undominated.

b. Similarly, MAX: [+ROUND] is also undominated. If the feature [+ROUND] is on the labial tier in the input, it will be there in some form of the output. In practice this means that
c. The constraint NoGAP is a universal in all languages, so it is undominated here as well.
d. At this point in time, there is no evidence to suggest that ALIGN-L [+ROUND] is not undominated since the data so far show no exceptions to the leftward spreading of [+ROUND]. We will see below however, that exceptions do exist, so ranking ALIGN-L [+ROUND] as undominated will later need to be changed. But for now we will consider it to be undominated.
e. Clearly, the constraint ID: [ROUND] is dominated by at least ALIGN-L [+ROUND], since we see [-ROUND] segments being realized as [+ROUND].

The constraint rankings, which hold across the nounclass prefix morpheme boundary and are therefore Word Level rankings, are as follows:

[+ROUND]/ [+BACK], MAX: [+ROUND], NoGAP, ALIGN-L [+ROUND] >> ID: [ROUND]

1.3 Tableaux

```plaintext
WORD LEVEL
/tèslrə/

<table>
<thead>
<tr>
<th></th>
<th>[+ROUND]</th>
<th>[+BACK]</th>
<th>MAX: [+ROUND]</th>
<th>NoGAP</th>
<th>ALIGN-L [+ROUND]</th>
<th>ID: [ROUND]</th>
</tr>
</thead>
<tbody>
<tr>
<td>təsrə</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>təsrə</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>təsrə</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| təsrə | | | * | * | * | *
| təsrə | | | | * | * | *
| təsrə | | | | | * | * |
| təsrə | | | | | | * |
| təsrə | | | | | | * |

/țlőpənɨ/

<table>
<thead>
<tr>
<th></th>
<th>[+ROUND]</th>
<th>[+BACK]</th>
<th>MAX: [+ROUND]</th>
<th>NoGAP</th>
<th>ALIGN-L [+ROUND]</th>
<th>ID: [ROUND]</th>
</tr>
</thead>
<tbody>
<tr>
<td>țlőpənɨ</td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>
| țlőpənɨ | * | | | | | *
| țlőpənɨ | | | | | | *
| țlőpənɨ | | | | | | *
| țlőpənɨ | | | | | | *
| țlőpənɨ | | | | | | *
| țlőpənɨ | | | | | | *
```
Exception of \( a \)

Exceptions to rounding harmony as it has been described fall into two classes. The first is that [+ROUND] does not spread onto or through the vowel \( a \).

\begin{equation*}
\begin{array}{c}
\text{k\textcircled{j}w\textcircled{r}} \\
\text{k\textcircled{k}r\textcircled{\textae}} \\
\text{k\textcircled{k}t\textcircled{\textae}} \\
\text{body} \\
\text{village} \\
\text{eye}
\end{array}
\end{equation*}

1.4 Additional constraints

* [+Low, +Round]  The output may not contain vowels that are both [+Low, +Round].

ID: Low  The input and the output must be identical with respect to the specification for the feature [Low].

1.5 Ranking

a) In addition to the constraints recognized above, we need to recognize * [+Low, +Round]. Since one never sees low round vowels in the language, one can safely assume that this constraint is undominated.

b) In environments where \( a \) could potentially be realized as [+Round] (i.e., to the left of a [+Round] vowel), one does not see the vowel becoming [–Low, +Round] (i.e., 1). Instead it remains [+Low, –Round]. In fact, one never sees any vowel changing its specification for [Low]. The [+Low] \( a \) remains [+Low], and all the other vowels, which are [–Low], remain [–Low]. This tells us that the constraint ID: Low is also undominated.

c) The fact that [+Round] does not spread onto \( a \) shows us that Align-L [+Round], which we have so far been treating as undominated is in fact dominated by * [+Low, +Round]. Recall, however, that Align-L [+Round] dominates ID: [Round]. This means that we now have the following rankings:

Undominated Constraints >> Align-L [+Round] >> ID: [Round].

1.6 Tableau

\[
\begin{array}{c|c|c|c|c|c|c}
\hline
\text{Word level} & \text{ID: [Low]} & \text{Align-L [+Round]} & \text{Max: [+Round]} & \text{NoGap} & \text{+[Round]} & \text{ID: [+Round]} \\
\hline
/k\textcircled{k}t\textcircled{\textae}/ & & & & & & \\
\hline
\text{k\textcircled{k}t\textcircled{\textae}} & *! & & & & * & ** \\
\text{k\textcircled{k}t\textcircled{\textae}} & *! & & & & * & ** \\
\text{k\textcircled{k}t\textcircled{\textae}} & & & & & *! & * \\
\text{k\textcircled{k}t\textcircled{\textae}} & & & & & *! & * \\
\text{k\textcircled{k}t\textcircled{\textae}} & & & & & *! & * \\
\text{k\textcircled{k}t\textcircled{\textae}} & & & & & *! & * \\
\hline
\end{array}
\]
2. Exception of \([-\text{ROUND}]\) Consonants

In the data sets above, all the consonants that occur to the left of the right-most round vowel are non-labial and therefore not a problem for rounding harmony. However, in the data set immediately below, the labial consonants \(p, b, f, kp\) block rounding harmony. The second exception to rounding harmony is therefore that rounding harmony does not spread past consonants that have the Labial specification \([-\text{ROUND}]\). Recall that only Labial consonants are specified for the feature \([\text{ROUND}]\). Since labial consonants are specified for rounding, the labial consonant \(w\), is \([+\text{ROUND}]\) and the other labial consonants, \(p, b, f,\) and \(kp\), are all \([-\text{ROUND}]\).

\begin{align*}
dʒépů & \quad \text{tongue} \\
kısıbó & \quad \text{ear} \\
kífóří & \quad \text{rock} \\
kikpůní & \quad \text{knot}
\end{align*}

2.1 Additional constraint

ID: \([\text{ROUND}]\) (C) The input and the output must be identical with respect to the roundness of consonants.

2.2 Ranking

Since consonants never change their rounding specification, one can safely assume that ID: \([\text{ROUND}]\) (C) is undominated in Chumburung.

2.3 Tableau

\begin{center}
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline
\textbf{WORD LEVEL} & \multicolumn{3}{c}{ID: \([\text{ROUND}]\) (C)} & \multicolumn{3}{c}{ID: \([+\text{LOW}, +\text{ROUND}]\)} \\
\hline
/kısıbó/ & \multicolumn{3}{c}{ID: \([-\text{LOW}, +\text{ROUND}]\)} & \multicolumn{3}{c}{ID: \([-\text{ROUND}]\)} \\
\hline
\hline
küsůwů & *\dagger & \multicolumn{2}{c}{**} & \multicolumn{2}{c}{**} \\
\hline
kısıbê & \multicolumn{3}{c}{*\dagger} & \multicolumn{2}{c}{**} \\
\hline
küsúbů & \multicolumn{3}{c}{*\dagger} & \multicolumn{2}{c}{**} \\
\hline
kısıbó & \multicolumn{3}{c}{**} & \multicolumn{2}{c}{**} \\
\hline
\hline
\end{tabular}
\end{center}
Optimality Theory and Ethical Decision Making

Steve and Mónica Parker
SIL, Papua New Guinea Branch

Peter and the other apostles replied: “We must obey God rather than men!” (Acts 5.29)

Optimality Theory (OT) is a formal linguistic model in which grammars consist of a universal set of violable constraints that are ranked in a language-particular hierarchy. Lower-ranked constraints are often forcibly violated in order to improve satisfaction of higher-ranked constraints. The optimal or most harmonic pronunciation of a given word is that output candidate which best fulfills the language-specific ranking for a selected input form.

In this paper we show how OT can be invoked and efficaciously applied to the task of moral decision making in those situations when two or more principles conflict. For example, Christians are expected to have fellowship with other believers. At the same time, Christian wives are supposed to submit to their husbands. Now what if a Christian woman is married to an unbelieving husband who tells her not to go to church? In cases such as these, it is impossible to fulfill both requirements simultaneously. Consequently, we claim that moral failure or sin cannot be directly correlated with disobedience in and of itself. Disobedience is a necessary, but not a sufficient, condition for sin. Rather, we propose a novel and precise definition of “sin” as choosing a biblically non-optimal course of behavior.

1. The problem

The primary function of moral codes is to help us know what types of behavior are considered good and bad in specific circumstances. There are many different kinds of ethical systems to which one may ascribe, depending on one’s political, cultural, and religious presuppositions. Hence, moral codes vary widely. Some are informal and handed down as oral traditions from one generation to the next. Others are rigidly codified as written texts considered sacred by their adherents, e.g., the Koran. Some codes are limited to very narrow aspects of our lives and violation of them can be relatively harmless, such as standards for proper attire. Others are intended to be more serious and comprehensive statements about every detail of our existence. Given the limitless variety of circumstances which may arise in human lives, it is impossible for any one given code to cover every conceivable decision with precise guidelines. Thus in order for a moral code to be practical, it should anticipate novel scenarios and provide general instructions for dealing with them. Furthermore, situations may occur in which two or more ethical principles contradict each other, and a well-designed code should also inform its followers what to do in a case of this type. As Lutzer 1981:88 puts it, “In any discussion of… ethics, the question arises as to what kind of conduct pleases God in those special situations in which two universal moral laws appear to be in conflict.”

1The notion that Optimality Theory could be invoked to evaluate moral decisions was first suggested to us by Amalia Gnanadesikan. We would like to thank her, as well as Albert Bickford, Mike Cahill, Paul de Lacy, Karl Franklin, James Hafford, Clif Olson, Mary Raymond, Jeff Sickmeier, Keith Snider, Gerhard Tauberschmidt, and René van den Berg for further discussion of the issues raised here. Please do not assume that these people necessarily agree with us about any of these ideas. Scripture quotations are from the New International Version.

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One large and very well known repository of moral teachings is of course the Bible. For the sake of concreteness and consistency, our discussion here will primarily be focused on biblical principles. Nevertheless, the system of interpretation we propose is of such general and practical scope that it could easily be applied to other types of decisions, even those which are not strictly speaking ethical in nature. For example, the manager of a company could invoke the principles we espouse to utilize resources such as time, personnel, equipment, physical space, etc., in the most efficient way. However, moral decisions are especially important and interesting since they test our character and, many people believe, have far-reaching implications in our lives.

The purpose of this paper is to discuss a few hypothetical scenarios in which two or more ethical principles appear to conflict with one another and suggest a practical way to resolve them. To take one example from the Bible, Christians are exhorted to have fellowship with other believers on a regular basis (Matt. 18.20; Acts 2.42, 44, 46; Hebr. 10.24–25). At the same time, Christian wives are commanded to submit to their husbands (1 Cor. 11.3; Eph. 5.22–24; Col. 3.18; 1 Pet. 3.1). Now what if a believing woman is married to a non-Christian man who tells her not to go to church? This obviously presents a dilemma. The central claim of this article is that in circumstances of this type, it is impossible to simultaneously fulfill (obey) every relevant commandment of the scriptures. Rather, in situations where two doctrines logically conflict with one another, the believer must disobey one of them so that he or she may comply with the other, more important, commandment (assuming that there is some coherent system in place to dictate which teachings are the most critical). For example, in our hypothetical setting, we argue that the wife is permitted and even compelled by the Bible to disregard the husband’s injunction not to attend church, so that she can maintain a clear conscience with respect to commandments contained in other relevant verses. We do not mean to imply here that this issue is simply quantitative in nature—violate the fewest number of verses possible. Rather, it is clearly a qualitative matter—some commandments are inherently more important in God’s eyes than others, numbers aside. Ramsey 1953:47 anticipates this concept when he states that every legal system needs to include “...rules establishing some order of preference among the laws in case conflict makes necessary a breach of one or more of them.”

We propose that Optimality Theory (OT) be adopted to provide a formal framework for analyzing and evaluating moral decisions of this type. The principal tenet of OT is that linguistic grammars consist of a series of ranked and violable constraints which jointly select the best output or phonetic form for each input. In this paper we claim that OT can be efficaciously applied to the task of biblical interpretation in those cases when two or more potentially antagonistic commandments need to be resolved. In the ensuing discussion we propose a novel, precise, and theory-internal definition of “sin” as choosing a scripturally non-optimal course of behavior.

The remainder of this paper is organized as follows. In §2 we set the stage by outlining the presuppositions and formal machinery of OT. In §3 we then show how OT can be invoked as a basis for prioritizing ethical considerations, especially when these might otherwise leave us in a potentially frustrating dilemma. We summarize in §4.

2. Optimality Theory and Linguistic Grammars

In this section we briefly review the central claims and formal devices of OT. The opus classicum of Optimality Theory is Prince and Smolensky 1993. Two recent and comprehensive textbooks are Kager 1999 and McCarthy 2002. OT was initially applied to phonology. It is now firmly entrenched in generative syntax as well, and has lately made its way into semantics.

2See Geisler 1971 for a discussion of other ways to deal with moral conflicts.
An OT grammar consists of a language-specific ranking of the universal set of constraints, known as CON. However, in contrast to most previous models, OT constraints are potentially violable. Therefore, lower-ranked constraints may be forcibly violated if this would improve satisfaction of higher-ranked constraints. Nevertheless, constraint violation must still be as minimal as possible. For example, when the plural suffix /-z/ is added to English nouns, a sequence of two sibilants is sometimes created: /ʃʌʃ/ → *[ʃʌʃz]. When this happens, an epenthetic reduced vowel is introduced to repair the illicit sibilant cluster: [ʃʌʃz]. This tells us that in English, the constraint which outlaws two [+strident] segments in a row (possibly the Obligatory Contour Principle) takes precedence over the natural pressure not to insert vowels. Nevertheless, epenthesis only applies at most once in each plural form since multiple insertion as in *[ʃʌʃz] gratuitously violates the constraint against epenthesis without any compensating improvement on the prohibition against adjacent sibilants. In other words, overkill is not tolerated.

In OT there are two types of constraints. MARKEDNESS (or structural) constraints tell us that certain features, structures, or configurations either must or must not be present in output forms. For example, ONSET requires all syllables to begin with at least one consonant, whereas NOCODA militates against syllables which end with a consonant. The prohibition against adjacent [+strid] specifications is another type of markedness constraint. FAITHFULNESS constraints, on the other hand, tell us that it is bad to either add or delete segments or otherwise modify the input → output mapping. Thus the English word [ʃʌʃz] entails a violation of the faithfulness constraint which rules out epenthetic vowels. The interleaving of the whole universal series of markedness and faithfulness constraints produces the grammar of a specific language. Furthermore, permuting the relative rankings of these constraints accounts for the diverse typology and variation we observe from one language to the next.

In OT, there are no phonological rules in the classical sense. Rather, phonological processes (alternations) occur because some constraints dominate (outrank) other constraints. The central and only graphical formal device in OT is a type of table known as a tableau. Along the top row of a tableau we list the constraints that are most relevant to a particular input form. The left-to-right sequential order in which these constraints are displayed in a tableau corresponds to the hierarchical ranking of these constraints as posited for the language in question. The leftmost column of each tableau consists of a set of CANDIDATES or potential output (surface) forms for a given input. In theory the candidate set is infinite and universal, meaning that any and every conceivable output structure must be considered simultaneously. In other words, there are no language-specific restrictions on the list of candidates that need to be sifted through by the grammar. In actual practice, however, we normally include in a tableau only those output forms which are the most likely and/or relevant contenders for the underlying representation being considered. The following tableau illustrates the evaluation of the English word [ʃʌʃz] as outlined informally above:

<table>
<thead>
<tr>
<th></th>
<th>Input: /ʃʌʃz/</th>
<th>*SIB-SIB</th>
<th>DO NOT INSERT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>[ʃʌʃz]</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>[ʃʌʃz]</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

In tableau (1) above, we have posited a simplified markedness constraint called *SIB-SIB which rules out adjacent [+strid] consonants. In English this constraint outranks an antagonistic faithfulness constraint which basically says “Don’t insert a segment which was not present in the Input.” (The precise names and formulations of these constraints are tangential to our purposes here.) Tableau cells which contain one or more asterisks (*) indicate that the candidate at the far left in that row violates the constraint mentioned at the top of that column. Thus candidate (a) [ʃʌʃz] violates the *SIB-SIB markedness constraint since it contains the cluster [ʃz]. However, [ʃʌʃz] perfectly satisfies the faithfulness constraint against insertion since it is identical to the Input (underlying) form. Therefore, it does not violate DO NOT INSERT, so that
cell is left blank for this candidate. Candidate (b) [$\text{j:jiz}$], on the other hand, satisfies *SIB-SIB at the expense of violating the lower-ranked DONOTINSERT (it has introduced a vowel in order to break up the sibilant cluster). Note that candidate (a) violates a constraint higher in the hierarchy of English (i.e., farther to the left in the tableau) than candidate (b) does. Consequently, (a) is not chosen as the actual output in this case; it is ungrammatical. Its violation of *SIB-SIB knocks it out of the running compared to (b). The ! symbol indicates that this violation of *SIB-SIB is fatal to (crucial to eliminating) candidate (a). Candidate (b) also has one violation mark in this tableau, for the constraint DONOTINSERT (whose locus of infraction is the epenthetic [ɨ]). This is not as serious as violating *SIB-SIB because in English, *SIB-SIB outranks (dominates) DONOTINSERT. Consequently, (b) is selected as the best (optimal) candidate for this particular Input since it has fulfilled the relevant constraints in the most harmonic way, i.e., better than all other contenders (given this language-specific ranking). The winning candidate in each tableau is (redundantly) indicated by the symbol ☉. Thus, in English the word meaning ‘judge plural’ is pronounced [$\text{j:jiz}$].

This is a very simple and compact illustration of how OT works. In a complete analysis we normally consider many more constraints and candidates. For example, another possible way to repair the marked sibilant cluster in /$\text{j:j}z$/ is to delete either the /$z$/ or the second /$\text{j}$/. In English these options are ruled out by a faithfulness constraint blocking segmental deletion which dominates DONOTINSERT. In some other language with a different ranking of these constraints, an input like /$\text{j:j}z$/ might have a different evaluation and thus a different outcome. Nevertheless, tableau (1) establishes the fact that in English, *SIB-SIB dominates DONOTINSERT. This crucial ranking is symbolically encapsulated in OT in this way: *SIB-SIB >> DONOTINSERT. Consequently, in English it is more important to satisfy *SIB-SIB than it is to satisfy DONOTINSERT, all else being equal. Conversely, violating DONOTINSERT is tolerated more than violating *SIB-SIB (in English). Nevertheless, DONOTINSERT can still make its presence felt, even though it is (relatively) low-ranked; the hypothetical candidate *[J:jiiiz], with three epenthetic vowels, is also non-optimal since it violates DONOTINSERT more than the attested winner [$\text{j:jiz}$] does. Hence, violation of lower-ranked constraints can be compelled, but violation is always as minimal as possible, ceteris paribus.

An interesting side effect of this latter point is that OT excels at capturing linguistic interactions or conflicts of the type “Do (or do not do) x except when y”. In the example above, for instance, we could express the generalization for English as “Do not insert any vowels except when two sibilants would otherwise end up being adjacent in the output form” (obviously this is only one small piece of the grammar). In previous models, “exceptions to the rule” often led to cumbersome, inelegant analyses since they required us to invoke different types of formal mechanisms for dealing with a unitary phenomenon. For example, in languages where a peripheral syllable is always skipped over by “exhaustive” metrical parsing, this had to be accounted for by extraprosodicity. This suggests that grammars are non-isomorphic. In OT, on the other hand, all linguistic facts are captured by a single, uniform device: ranked and violable constraints. Consequently, every constraint in the universal inventory of CON expresses a linguistically significant tendency or generalization that holds true of all languages, modulo other constraints. Thus the only difference between languages lies in their ranking of these constraints. The following list enumerates a series of phonological patterns of the type “Do (or do not do) x except when y” which have been observed in many languages:

3In OT there is normally just one optimal winning candidate which gets pronounced for any given input form. However, in cases when certain constraints are tied (co-ranked), there may be two alternative surface forms for a specific word. This would be necessary, for example, in situations of free variation.
(2)  
- Onsetless syllables are prohibited except word-initially.
- Every syllable in a prosodic word must be parsed into some metrical constituent except when this would lead to a degenerate (monomoraic) foot.
- Adjacent identical segments are prohibited except across morpheme boundaries.
- Delete a word-final vowel except when this would leave a sub-minimal word.
- Every metrical foot must contain a head except when this would produce a stress clash.
- The segment [ʔ] is prohibited except phrase-initially.

If this paper were focusing on phonology per se, we would supplement the list in (2) with examples of languages which illustrate these phenomena. We would also naturally discuss the relevant constraints and their rankings which produce these effects. To include all of these details here, nevertheless, would take us too far afield of our principal concern, which is OT and moral decisions. Any interested reader can pursue these points in the extensive OT literature. Our main focus in this section has simply been to illustrate the nature of an OT grammar. As we will now see, analyzing other aspects of human behavior as the interaction of possibly conflicting constraints has useful applications outside of linguistics proper.

3. OT and the Bible

The Bible is full of doctrines, teachings, commandments, and prohibitions. Some of these have the potential to interact with one another in the general sense that we have just discussed: “Do (or do not do) x except when y”. Here are some examples:

(3)  
- Divorce is prohibited (Deut. 22.19, 29; Mal. 2.16; Matt. 19.6; Mark 10.9; Rom. 7.2–3; 1 Cor. 7.10–13, 27) except in the case of porneia (Matt. 5.32, 19.9).
- All human beings are sinful (1 Kings 8.46; Psalm 14.1–3, 53.1–3, 143.2; Eccl. 7.20; Rom. 3.23; 1 John 1.8) except Jesus (John 8.46; 2 Cor. 5.21; Hebr. 4.15, 7.26, 9.14; 1 Pet. 1.19, 2.22).
- Killing another human being is wrong (Gen. 9.5–6; Ex. 20.13; Deut. 19.11–13; Matt. 19.18) except as a punishment for certain offenses (Ex. 21.12–17; 21.12, 35.2; Lev. 20.9–16; Num. 35.16–21; Deut. 13.6–10, 17.12, 21.18–21).
- It is permitted to eat any food (Matt. 15.11, 17–20; Mark 7.15–19; Acts 10.15; Rom. 14.14, 20; 1 Cor. 8.8, 10.25; 1 Tim. 4.3–5) except when this would offend another believer (Rom. 14.13–17, 19–21; 1 Cor. 8.9–13).
- No human being is allowed to enter the Holy of Holies except the high priest (Hebr. 9.7).
- Christians should not judge one another (Matt. 7.1–5; Luke 6.37; Rom. 2.1–3, 14.13; James 4.11–12) except in the case of certain sins within the church (1 Cor. 5.1–5, 9–13).

In some of these cases there may be more than one “exception clause.” For example, the prohibition against killing has been argued not to apply to soldiers, at least in combat settings. Some Christians (but not all) would also hold to the following belief:

(4)  
- Abortion is prohibited except to save the physical life of the mother.

Another case of this type is that the Bible in general admonishes us not to lie (Ex. 20.16; Lev. 19.11; Psalm 101.7; Prov. 12.22, 19.5, 9; Zech. 8.16; Eph. 4.25; Col. 3.9). Nevertheless, God blessed Rahab, her whole family, and all of Israel when she lied to protect the men who were spying out the promised land...
Similarly, a Jewish rabbi argues that it’s okay to lie when the purpose is *pikuach nefesh* ‘saving lives’ (Telushkin 2000). Now consider the following injunctions:

(5)  
- Wives should submit to their husbands (1 Cor. 11.3; Eph. 5.22–24; Col. 3.18; 1 Pet. 3.1) *except* when ???
- Children should obey their parents (Prov. 6.20; Eph. 6.1–3; Col. 3.20) *except* when ???
- Christians should submit to the governing authorities (Rom. 13.1–7; Tit. 3.1; 1 Pet. 2.13–14, 17) *except* when ???

A major goal of this section is to confront issues such as those listed in (3)–(5) above and show that OT provides a framework for making sense of moral “conflicts” of the type “Do (or do not do) x *except* when y”. Our personal belief is that, like other consistent ethical codes, the Bible does not contradict itself. What OT offers us in terms of the process of scriptural hermeneutics is a principled, systematic approach to prioritizing the various commandments of the Bible into a logical, coherent hierarchy in which some “constraints” outrank or dominate others. In other words, our claim is that not all biblical commands are necessarily equal in force; some commands are more important to follow than others, *if and when* it is impossible to obey both of them simultaneously. One of the best illustrations of this principle comes from the words of Jesus himself:

> One of them, an expert in the law, tested him with this question: “Teacher, which is the greatest commandment in the Law?” Jesus replied: “‘Love the Lord your God with all your heart and with all your soul and with all your mind.’ This is the first and greatest commandment. And the second is like it: ‘Love your neighbor as yourself.’” (Matt. 22.35–39)

In the passage quoted above, Jesus’ answer suggests that there is something inherently different about these two commandments. The principle he establishes here is that in some sense it is more important to love God than it is to love your neighbor. This implies a hierarchy of prioritization. It also implies that, in theory, there could arise a situation in which someone might have to choose between these two goals or objectives. Otherwise, if it never makes any practical difference whom we love more, why would Jesus have bothered to make this distinction? One conclusion that clearly emerges from this passage is that if these two commandments should ever come into conflict in such a way that we are forced to obey one of them at the expense of the other, loving your neighbor must give way to loving God. That is, drawing on the tenets of OT, the commandment to love your neighbor is violable and can (and should) be disobeyed, if necessary, in order to improve satisfaction of the higher-ranked “constraint” to love God. However, just as in phonology, violation must be as minimal as possible, all else being equal. Overkill is never optimal. The command to love our neighbor should *always* be fulfilled *except* when obedience to the more important commandment (loving God) is at stake.

A similar interplay of forces is at work in Luke 14.26: “If anyone comes to me and does not hate his father and mother, his wife and children, his brothers and sisters—yes, even his own life—he cannot be my disciple.” Given the numerous other scriptural exhortations to love, honor, and respect our parents, spouses, etc., what are we to make of Jesus’ using the word “hate” in this context (which is clearly an

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4When Jesus says that the second commandment is *like* the first one, we do not take this to mean that they are equal in force or ranking. If that were the case, how could the first one be *greater* than the second one? Rather, they are alike in the sense that both involve loving someone else more than yourself.
instance of hyperbole)? Obviously, we do not need to literally hate all of these people. Rather, there is an implied comparison here: our love for Jesus should be so great that it outweighs our love for family and in effect makes our love for others seem miniscule in degree. Again, an implicit conclusion here is that in principle a situation could arise in which these two types of love come into conflict and one of them has to be relaxed (temporarily abandoned).

Let us now move from the realm of theory alone and illustrate our claims with a more concrete example. Recall the scenario from §1: suppose a non-Christian man orders his Christian wife to stay away from church (or from all other believers at all times). At this point two scriptural injunctions come into conflict: have fellowship with other believers (Matt. 18.20; Acts 2.42, 44, 46; Hebr. 10.24–25) and submit to your husband (1 Cor. 11.3; Eph. 5.22–24; Col. 3.18; 1 Pet. 3.1). In this situation, it would be impossible for the wife to simultaneously obey both commandments. No matter what she does, she must disregard one of them. We hope that the correct decision is clear and obvious in this case: the need for contact with other Christians frees the wife from the requirement to submit to her husband (on this one detail). In OT terms, we posit that verses like Matt. 18.20, Acts 2.42, 44, 46, and Hebr. 10.24–25 outrank or dominate 1 Cor. 11.3, Eph. 5.22–24, Col. 3.18, and 1 Pet. 3.1. An interesting question which arises in conjunction with this issue is, how are we, as fallible human beings, to know the correct ranking of biblical constraints? Phonological OT has different classes of constraints—faithfulness, markedness, alignment, etc. Perhaps most (or all?) scriptural injunctions similarly fall into only two families of related commandments: LOVEGOD (or OBEGOD) and LOVEOTHERS. There may be other constraints which fit into neither of these classes, but it is hard to think of any examples! Furthermore, unlike most linguistic constraints, the two categories of biblical constraints are (probably!) universally fixed in their ranking such that LOVEGOD commandments always dominate LOVEOTHERS, and thus the two types can never be permuted (reversed). If this is true, it would greatly help the individual Christian in his or her “acquisition” of the correct scriptural hierarchy, and strongly restrict the number and types of possible ethical systems which could logically be derived from personal study and application of the Bible.5

Returning now to the specific example just discussed, to play the devil’s advocate, a skeptic might argue that this situation is hypothetical and may never arise in real life. However, we personally know of at least one Christian pastor who advised a woman in his congregation not to attend church because her husband forbade it. In general we consider this particular “constraint ranking” to be wrong, as argued in the preceding paragraph. (In this specific instance, nevertheless, there was a mitigating factor: the husband was physically abusing his wife. This suggests some type of self preservation constraint which is even more crucial than going to church—another example of “Do x except when y”.) At the same time, however, in this case there may be a compromise solution available, based on the fact that fellowship is not an all-or-nothing proposition. The New Testament liberates the Christian from legalistic adherence to certain requirements (Col. 2.16). For example, nowhere does it teach us that we must attend church every single Sunday without fail. Therefore, a Christian wife in this situation might choose to go to church on certain days but not on others, opting to stay at home with her husband on those occasions. However, although submission to husbands is subordinated to having fellowship (ex hypothesi), this does not give wives the freedom to blithely disregard the former constraint (or any other constraints, for that matter).

5For example, another hypothesis which we might initially consider is that the New Testament always takes precedence over the Old Testament. This principle is suggested by Jesus’ frequent statements to the effect that “It has been said (or taught) x, but now I say to you y.” The corresponding generalization is, obey the commandments of Moses except when these are superceded by the commandments of Jesus. Sometimes, however, this appears to work in the opposite way: do not commit divorce (which clearly seems to have been Jesus’ preference) except for the law of Moses (infidelity).
Rather, the principle of minimal violation is still in force. In other words, “loving God” should not be an excuse to be callous and indifferent to those around us.

Another verse which is relevant (and likewise violable) here is Rom. 12.18: “If it is possible, as far as it depends on you, live at peace with everyone.” These principles are compatible with and have precedents in OT since certain linguistic constraints are gradiently (as opposed to categorically) violable. For example, the alignment of metrical feet with prosodic edges is often imperfect and has to settle for “just doing the best that can be done.” In the same way, certain commandments of scripture, such as “pray without ceasing” (1 Thess. 5.17), cannot literally be fulfilled 24/7, so in a sense they are soft or flexible constraints as well.

Returning to the hypothetical example that we have invoked throughout this paper, we might ask now, what alternative is there to an OT view of the scriptures? If one tenaciously contends that commandments such as Eph. 5.22–24, etc., are meant to be inviolable, what is the Christian wife to do? She can fulfill these verses by submitting to her husband, but only at the expense of disobeying other injunctions such as Hebr. 10.24–25, etc. Furthermore, it can get even worse than this; what if the husband tells her to completely denounce her faith, or murder some innocent bystander, or…? Given the political climate of religious persecution in some countries, these are not completely outlandish propositions. Scenarios of this type present a moral dilemma. We contend that in such situations, disobedience to some commandment(s) of the Bible is unavoidable. One advantage which OT offers us in this context is freedom from (inappropriate) guilt. In phonology, the most universally unmarked word is probably [tata]; all other output forms violate at least one markedness constraint. Thus, every word we speak violates some linguistic constraints. Similarly, in real life, just as in phonology, the optimal choice is sometimes not absolutely perfect, but rather one which simply does the best that can be done, given the circumstances. Often we must violate one commandment or constraint in order to do better on certain others. What ultimately determines the best candidates for us, both in linguistic grammars and in ethical applications, is the hierarchy or ranking of the relevant constraints. With respect to the Bible, only God knows for certain what the complete and correct hierarchy is. Nevertheless, with the knowledge available to us, one small piece of a scripturally based, OT view of life might be characterized by the following constraint rankings:

(6) God >> spouse >> children >> other human beings >> self

One small confirmation of the scale in (6) is that in the list of the Ten Commandments, those which relate to God appear before those which relate to other people. In applying the general hierarchy in (6) to our daily lives, it must be emphasized that in OT, all constraints are universal forces or tendencies which only hold true when all else is equal. Thus, there may be a more specific constraint which falls in the middle of (6) and thereby has the apparent effect of a local reversal in a particular situation. For example, on the one hand our relationship with our spouse is higher than that with our children since we are married for life whereas our children will eventually grow up and go their own way. On the other hand, we simultaneously have a duty to defend, protect, and provide for our children in a way that we don’t have to for our spouse, who is (hopefully) a mature adult capable of looking after him/herself. To summarize the paper thus far, we certainly do not wish to claim that all of the commandments in the Bible are intended by God to be potentially violable, but some of them at least have to be.

We are now in a position to provide a novel, precise, and OT-driven definition of moral failure or “sin”. We begin by emphasizing our belief that it should always be possible, in any given situation, for

Ironically, in the Wuvulu language of Papua New Guinea, the word tata means ‘error’ or ‘sin’! (James Hafford, personal communication)
someone to choose at least one course of behavior which is not sinful. That is, no matter what the circumstances, it is always the case that we have at least one option available to us by which we can fulfill the moral code we are following. In many cases there are multiple righteous alternatives available. At the same time, however, we have shown that in some conceivable scenarios it is not possible to obey every relevant commandment of the Bible. In other words, in some cases the Christian is necessarily compelled to disregard at least one scriptural constraint. Consequently, sin cannot simply be defined as or correlated with disobedience to a specific scripture (or some other ethical dictum). While it is true that sin always entails disobedience, disobedience in and of itself does not always entail sin! Disobedience is a necessary, but not a sufficient, condition for defining sin. As a result, sin (for the Christian) can now be regarded as choosing a biblically non-optimal course of action. In other words, sin is tantamount to behaving in a manner which can be formally equated with a fatal violation of the Bible’s hierarchy of ranked constraints. In principle the commandments of scripture should be correctly ranked in an *a priori* fashion which is the same for all Christians. We realize that in actual practice this is often subject to free variation and individual interpretation. For instance, passages such as Rom. 14.1–23, 1 Cor. 8.1–13, and 1 Cor. 10.23–33 teach us that in certain cases there are valid differences among Christians in the sense that some constraint rankings may be person-specific. Nevertheless, to give one concrete general example, consider again the scenario with which we began this exposition: a Christian wife is informed that her husband does not want her to meet with other believers. As argued above, we posit that the ranking which is most consistent with the Bible overall is *HAVEFELLOWSHIP >> OBEYHUSBAND*, because this is an instance of loving God more than loving man. Consequently, we can now illustrate two of the most straightforward options available to a Christian wife in this situation by means of a tableau:

<table>
<thead>
<tr>
<th>(7)</th>
<th>HAVEFELLOWSHIP</th>
<th>OBEYHUSBAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>☞ go to church</td>
<td>*</td>
</tr>
<tr>
<td>b.</td>
<td>don’t go to church</td>
<td>![star]</td>
</tr>
</tbody>
</table>

Given the crucial ranking of the two most relevant constraints, the option of choice for the wife is candidate (a): go to church (at least on some occasions). While this entails a violation of OBEYHUSBAND, and therefore disobedience to one set of verses, this commandment is ranked below HAVEFELLOWSHIP. Therefore this is not a fatal violation, so the wife has not sinned (assuming that she is operating with this constraint ranking). Hence she does not need to feel any guilt about not submitting to her husband on this detail. If sin were strictly equated with disobedience to any commandment of the scriptures, a wife in this situation would be in the infelicitous position of necessarily having to sin, one way or the other. On the other hand, if she selects candidate (b)—not going to church—in order to completely satisfy the lower ranked OBEYHUSBAND, she thereby violates the top-ranked HAVEFELLOWSHIP. This is a biblically non-optimal or sub-harmonic course of behavior, and therefore we could conclude that a sinful choice has been made.8

In this little exercise we have purposely glossed over other logical possibilities for the sake of simplicity. For example, what if a particular woman has these two constraints ranked in the opposite order? And what about the option of gradient violability—partially obeying both constraints at the same time, as

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7For example, Rom. 14.5 says, “Each one should be fully convinced in his own mind.” Cf. Rom. 14.14: “But if anyone regards something as unclean, then for him it is unclean.”

8In light of this definition of sin, it would be interesting to examine some of Jesus’ actions which the Pharisees regarded as sinful, e.g., healing on the Sabbath, overturning the tables in the temple, etc. Undoubtedly he was in fact making optimal choices based on the correct rankings of the relevant Old Testament passages.
we alluded to earlier? All of these issues are also important, but tangential to our main objective. Namely, we hope to have given a brief idea of how Optimality Theory can be effectively applied to the task of moral decision making.

4. Conclusion

Before we finish, we need to emphasize an important disclaimer: we do not presume to imply that OT is a panacea for all of life’s problems. The parallel between linguistic grammars and ethical decision making is neither exact nor complete. Not all situations can be neatly compressed into a choice between just two options or two constraints. Nevertheless, to the degree that it is appropriate, OT can help us analyze and unravel scenarios that are potentially quite complex, resolving them in a principled way that is consistent with the individual’s conscience. In this sense the arguments we have proffered here can by extension easily be applied to any moral system or evaluative process. The Bible was chosen as an illustration simply because it is familiar to many of us and hence convenient.

As a final detail, we note that in this paper we have not considered whether biblical commands can and should be compartmentalized into the two categories markedness vs. faithfulness. While such an analogy to linguistic constraints is intriguing and potentially useful, we will refrain from speculating on exactly how far this concept can be fruitfully pushed at this time. Nevertheless, we do point out that this would be a very interesting prospect for future research.

References


9In phonology, it is common practice to allow two constraints to be tied or co-ranked in particular languages. While this is generally considered undesirable, it is nevertheless often resorted to when the available empirical data simply run out before we encounter crucial evidence for the ranking of certain pairs of constraints. Nevertheless, in this specific biblical example, we would argue that co-ranking of these two constraints is not a logical possibility. It is impossible for a woman in this situation to satisfy both commandments, just as it would be impossible for her to simultaneously disobey both commandments. The fact of the matter is that in this scenario, life forces her to choose one action or the other: she either goes to church (always or sometimes) or she doesn’t (never). These two constraints are thus necessarily in conflict.

10The definition of ethical lapse which we have proposed in this paper is compatible with the notion of cultural relativity, up to a point. For example, in one ethnic group stealing may be considered a worse sin than lying, while some other culture may have these two constraints ranked in the opposite order. At the same time, however, verses such as James 2.10 teach us that in a certain sense, all sins are equally bad in God’s eyes.

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Phonology humor

compiled by Steve Parker

Over the years in which I have taught phonology, I’ve collected the following list of “bloopers” from students’ answers on homeworks, quizzes, and tests. Read them and weep.

Assimilation occurs when a contoid is absorbed by a neighboring contoid.

I note that [h] and [ʔ] occur together in one phoneme, and separately elsewhere.

Only consonants occur in the onset position.

Rule B must have applied first otherwise you could not get rule B to apply since it would not follow an obstruent.

Glottal Stop Deletion: the word-initial glottal stop is deleted when preceded by a nasal in the word-final position of a prefix.

Order of rules is not crucial, except in the word /seg/ where the suffix is applied immediately for [sege] and after rule 2 in [seks] and rule 6 must precede rule 4.

A stop deletes word-finally in the coda between a nasal and an [s], or after a sonorant consonant.

Syllables with voiceless consonants attract stress more than syllables with vowels.

Stress may be placed on the first syllable of a given language.

There are no syllabic vowels (so far in the data).

This contrast in analogous environment is due to assimilation.

Onset is obligatory except syllable-initially.

A glottal is inserted word-initially when the onset is a vowel.

[dl] is occurring vowel-medially.

[t] and [č] contrast in assimilating environment.
Beam Me Up Scotty Rule: when the last two root-final phones are [+ voice] and proceed a
[–voice] consonant, then a [+ nasal] root-final consonant (if present) and the suffix are deleted.

Stress goes wherever it wants. Stress isn’t real.

Q: When a linguist is developing an orthography (practical writing system) for a previously
unwritten language, why is it important that he or she determine which segments contrast?

A: There is less margin of error to do individual speech patterns accounted for phonologically
scripted. Clearer patterns of non-redundancy occur.

A: So as to determine the stylistic content of a language based on the phonemic content, hence to
see which orthographies actually are separate phonemes as compared to allophones.

Q: Give three different criteria for determining which of the allophones of a phoneme should be
chosen as the underlying or basic form for representing the phoneme as a whole.

A: The grapheme for whichever allophone that the people whose language this appreciate and
like should be taken seriously.

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THINGS TO PONDER...........

-Is there another word for synonym?
-Isn’t it a bit unnerving that doctors call what they do “practice”?
-When sign-makers go on strike, is anything written on their signs?
-Where do forest rangers go to “get away from it all?”
-Why isn’t there mouse-flavored cat food?
-What do you do when you see an endangered animal eating an endangered plant?
-If a parsley farmer is sued, can they garnish his wages?
-Would a fly without wings be called a walk?
-Why do they lock gas station bathrooms? Are they afraid someone will clean them?
-If a stealth bomber crashes in a forest, does it make a sound?
-If a turtle is found without a shell, is it homeless or naked?
-Why don’t sheep shrink when it rains?
-Can vegetarians eat animal crackers?
-If the police arrest a mime, should they tell him he has the right to remain silent?
-Why do they put Braille instructions on drive-through bank machines?
-How do they get the deer to cross at those yellow road signs?
-Why do they sterilize the needle when they are going to give a convict a lethal injection?
-Why did kamikaze pilots wear helmets?
-Is it true that cannibals don’t eat clowns because they taste funny?
“Brute Force” Rules

The derivation of ‘Moses’ from ‘Middletown’

I. The naive solution

Given: /mídltawn/ (after stress placement)
(1) ídltawn - Deletion m
(2) ózɨs - Insertion mózɨs

II. A sophisticated solution

Given: /mídltawn/ (after stress placement)
(1) Lateral Deletion mídtawn
(2) Stop Assimilation mítawn
(3) Degemination mitawn
(4) Spirantization mísawn
(5) Rounding mísonn
(6) Vowel Harmony mósonn
(7) Syncope móswn
(8) Glide Deletion mósn
(9) Dental Assimilation móss
(10) Schwa - Epenthesis mósis
(11) Intervocalic Voicing mózɨs

Source:

“Winning isn’t everything; it’s the only thing.” – Vince Lombardi

“However, laryngeal consonants (ʔ, h) are also common epenthetic segments and have also been argued to be Placeless.” – Linda Lombardi (2002)

1. Introduction

Within Optimality Theory (OT), five phonological asymmetries have recently been codified in a unified approach known as positional faithfulness (Lombardi 1995, 1999; Padgett 1995; Beckman 1997, 1998). These five prosodic positions are the following:

- syllable onsets (vs. codas)
- lexical roots (vs. affixes)
- word-initial syllables (vs. non-initial syllables)
- stressed syllables (vs. unstressed syllables)
- long vowels (vs. short vowels)

Beckman (1998:5) asserts: “... in circumstances of positional neutralization, it is always the perceptually non-prominent position which undergoes reduction, while the prominent positions preserve a full range of contrasts.” This is especially common with segments bearing contrastive laryngeal specifications; these features tend to be maintained in onsets yet lost in codas (Lombardi 1999).

Nevertheless, in Chamicuro, syllable codas contain nearly every segment that onsets can, but in addition to this codas also allow the phonemic glottal consonants /h/ and /ʔ/ to appear in surface forms, whereas the latter two segments are systematically prohibited in onset position. The following languages of PNG similarly restrict a laryngeal consonant to syllable-final position: Migabac (McEvoy 2003), Arop-Lokep (Raymond and D’Jernes 2003), and Kube (Lee and Lee 1990). The goal of this paper is to present an analysis of these languages which simultaneously fulfills two theoretically-desirable objectives: (1) preservation of the onset/coda asymmetry as a nearly unviolated universal tendency, while (2) also allowing /h/ and /ʔ/ to be a principled exception to this generalization.

In order to account for the facts of these languages within OT, I will propose a revision to the constraint HAVEPLACE (Itô and Mester 1993; Padgett 2002) so that it specifically requires onset consonants to possess a (Supralaryngeal) Place node. My findings thus coincide with claims made by Zoll (1998), Kager (1999), de Lacy (2001), and Smith (2002), who argue that OT must allow for positional markedness constraints in UG. I will conclude then that both types of
positional constraints are required — faithfulness and markedness — with the proviso that these may refer specifically to onsets, but not directly to codas.

Outline of paper:

- In §2 I introduce the relevant facts of Chamicuro.
- In §3 I present a formal OT analysis based on the new constraint HAVEPLACE(ONSET).
- In §4 I consider and reject four alternative solutions.
- In §5 I briefly discuss the broader typological implications of my proposal with respect to the onset/coda asymmetry.
- I conclude in §6 with a brief summary of the contribution of the paper.

2. On the distribution of glottal consonants in Chamicuro

In this section my goal is to convince you of two things: (a) in Chamicuro, /h/ and /ʔ/ are contrastive phonemes, and (b) they occur only in coda position, never in onsets.

Table 1: Inventory of Chamicuro consonant phonemes

<table>
<thead>
<tr>
<th></th>
<th>bilabial</th>
<th>alveolar</th>
<th>alveopalatal</th>
<th>retroflexed</th>
<th>palatal</th>
<th>velar</th>
<th>glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>voiceless stop</td>
<td>p</td>
<td>t</td>
<td></td>
<td></td>
<td>k</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>voiceless affricate</td>
<td>tʰ</td>
<td>č</td>
<td>č</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>voiceless fricative</td>
<td>s</td>
<td>š</td>
<td>š</td>
<td></td>
<td>h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nasal</td>
<td>m</td>
<td>n</td>
<td>ñ</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lateral</td>
<td>l</td>
<td>l</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>flap</td>
<td>(ɾ)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>glide</td>
<td>w</td>
<td></td>
<td></td>
<td></td>
<td>y</td>
<td>(w)</td>
<td></td>
</tr>
</tbody>
</table>

(1) Inventory of Chamicuro vowel phonemes: /i e a o u/ plus contrastive length.

(2) /ʔ/ and /h/ contrast with Ø in syllable codas:

a. /ʔ/ [toʔsόна] ‘shinbone’ [tosόна] ‘pile of dirt’
   [mέʔsa] ‘sea lion’ [mésa] ‘table’
   [mέʔna] ‘woodpecker’ [ménu] ‘tongue’
   [uʃáʔki] ‘I dance’ [ušáki] ‘my vagina’

b. /h/ [maʔtόdli] ‘tapir’ [matόdli] ‘species of worm’
   [iʔlάpi] ‘bank, shore’ [ilάpa] ‘his/her branch’

(3) /ʔ/ and /h/ also contrast with vowel length, so they cannot be analyzed as a devoicing of the second mora of long vowels:
(4) /ɬ/ and /h/ contrast with each other as well, so they cannot be considered variants (co-allophones) of one another:

[sáʔpu] ‘lake’ [káʔpu] ‘bone’
[àʔtikána] ‘we’ [aʔtíni] ‘path, trail’

(5) Other syllable-final voiceless consonants contrast with /h/ and /ɬ/ (including obstruents), so the laryngeals cannot be analyzed as deucahdal allophones of some underlying oral segment(s) in coda position:

coda /ɬ/: [yélna] ‘man, husband’
coda /y/: [áYno] ‘mosquito’
coda /k/: [syekpůčle] ‘pot-bellied’
[umákšǒtúke] ‘my nephew (male speaker)’
[wáʔšoʔtádle] ‘I put it in’
coda /t/: [nětna] ‘how much?’
[umútle] ‘my daughter (male speaker)’
[túʔlu] ‘chest’
coda /s/: [páspatádli] ‘raft’
[láʔpáʔsáči] ‘drink (noun)’
[wánošá] ‘I watch, look’
[wátošamáʔti] ‘I wash (clothes)’

(6) There are no systematic restrictions on which types of onset consonants may occur immediately following /ɬ/ and /h/:

___ stop: [níʔpa] ‘louse (insect)’
[ayíʔti] ‘now, today’

___ fricative: [áʔsi] ‘tooth’
[maʔʃvéti] ‘owl’

___ affricate: [íʔča] ‘his/her string, rope’
[péʔča] ‘soft’

___ nasal: [pnaʔmúdłe] ‘swamp, marsh’
[útúʔmási] ‘I kiss’

___ lateral: [iʔlápi] ‘bank, shore’
[àʔlot≠ʔtä] ‘near, nearby’

___ glide: [mepôdlahýáka] ‘never’
[naʔyéni] ‘where?’

(7) /h/ and /ɬ/ may both appear in the same word:

[taʔwóʔko] ‘far, distant’
(8) /ɪ/ and /h/ may each occur multiple times in the same lexical item, so they do not pattern like autosegments, which typically are limited to just one occurrence per root:

[wàh\topòh\kaší\hti] ‘I smoke (tobacco)’
[àh\lotì\i\hta] ‘near, nearby’

(9) When the bimoraic maximal syllable template would be violated, /ɪ/ and /h/ must delete:

\[ \begin{align*}
\text{a. } /u-\̃a\̃k/ & \rightarrow [u-\̃a\̃k-i] \\
\text{b. } /i-\̃a\̃k-kana/ & \rightarrow [i-\̃ak-kána] \\
\end{align*} \]

l1singular-dance-epenthetic 3-dance-plural
‘I dance’ ‘they dance’

3. Formal analysis

In this section my goal is to present an OT account of this pattern of distribution of laryngeal consonants.

I assume a rather generic type of hierarchical tree having the following partial structure, drawing from the feature geometry models of Sagey (1986), McCarthy (1988, 1994), and Halle (1995):

(10)

In the tree in (10) I assume that only supralaryngeal segments possess a structural Place node. This is because of the widely noted fact that glottal consonants often behave phonologically as if they were placeless in terms of vowel copying, deuccalization, etc. (Steriade 1987, Yip 1991, Stemberger 1993, Halle 1995, Rose 1996, Ladefoged 1997)

(11) Some important constraints relevant for the languages discussed here:

\textit{markedness}

- \textbf{*LARYNGEAL} (*LAR): Laryngeal feature specifications are prohibited in Output forms, where the three privative laryngeal features are [spread glottis], [constricted glottis], and [voice]. (Lombardi 1999)
faithfulness

- **IDENTLARYNGEAL (IDENTLAR):** Output segments and their Input correspondents must agree in all laryngeal feature specifications, i.e., do not change a segment’s laryngeal features. (Lombardi 1999)

- **MAX:** Every segment in the Input must have a correspondent in the Output, i.e., segmental deletion is prohibited. (McCarthy and Prince 1994, 1995; Lombardi 1995; Beckman 1997, 1998)

- **IDENT(PLACE):** Output segments and their Input correspondents must agree in all Place feature specifications, i.e., do not change a segment’s place of articulation, where Place ∈ \{Labial, Coronal, Dorsal\}. (Lombardi 1995; Beckman 1998)


- **HAVEPLACE(ONSET)**

\[ \forall \text{ segment } x, \text{ where } x \in \text{ Output } \& \ x \text{ is syllabified in onset position}, \exists y \text{ such that } y \in \text{ Place } \& \ y(x), \text{ i.e., } x \text{ contains } y. \]

“Every onset segment in the Output must have some Place specification.”

\[ \forall = \text{ universal quantifier (‘for each’)} \]

\[ \in = \text{ ‘is an element of’} \]

\[ \exists = \text{ existential quantifier (‘there is some’)} \]

(13) **HAVEPLACE(ONSET) is irrelevant when /h/ or /ʔ/ occurs in syllable-final position.**

<table>
<thead>
<tr>
<th>Input: /nihpa/</th>
<th>HAVEPLACE(ONSET)</th>
<th>MAX</th>
<th>IDENT(PLACE)</th>
<th>*LAR</th>
<th>IDENTLAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [ni.pə]</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [ni.h.pə]</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. [nis.pə]</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>d. [nit.pə]</td>
<td></td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. [nith.pə]</td>
<td></td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(14) Thus far we have motivated two crucial rankings: MAX, IDENT(PLACE) » *LAR

Given Richness of the Base (Prince and Smolensky 1993; Smolensky et al. forthcoming), we must also contend with hypothetical input forms containing infelicitious laryngeal consonants in onset position. This is where the new constraint HAVEPLACE(ONSET) becomes relevant in eliminating completely faithful candidates. Richness of the Base is not just a peculiar way of making life difficult in OT. It is an uncontroversial fact that Chamicuro has no syllable-initial glottal consonants, and any analysis must account for this in some way. Richness of the Base says that there can be no language-specific restrictions on underlying (input) forms. It thus
constitutes the death of Morpheme Structure Conditions. Its motivation is to avoid the problem of duplication or redundancy which exists in languages where constraints on underlying forms actively persist throughout the course of the derivation (conspiracies).

(15) hypothetical

<table>
<thead>
<tr>
<th>Input: /nihapa/</th>
<th>HAVEPLACE(ONSET)</th>
<th>MAX</th>
<th>IDENT(PLACE)</th>
<th>*LAR</th>
<th>IDENTLAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [ni.apa]</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [nit³apa]</td>
<td></td>
<td></td>
<td>*</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>c. [nišapa]</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>d. [nihapa]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

One way to empirically access Richness of the Base is through the adaptation of loan words. The following examples confirm that input syllable-initial /h/’s in Spanish are converted into a supralaryngeal obstruent in Chamicuro:

(16) Spanish  Chamicuro  English
naranja  [alánša]  ‘orange’
jabón   [šawóña]  ‘soap’
cojo     [kóyo]  ‘lame, crippled’

Tableau (15) demonstrates the need for three other crucial rankings:

(17) a. HAVEPLACE(ONSET), MAX » IDENT(PLACE)
b. *LARYNGEAL » IDENTLARYNGEAL

To summarize the formal OT analysis, the relevant constraints and their crucial rankings for Chamicuro are as follows:

(18) HAVEPLACE(ONSET)  MAX
   \[ IDENT(PLACE)  \]
   \[ *LARYNGEAL  \]
   \[ IDENTLARYNGEAL  \]

I have thus demonstrated that the constraint HAVEPLACE(ONSET) produces all the correct results for Chamicuro. There are also many other languages in which glottal consonants are systematically restricted to coda position. Consequently, UG (CON) must be modified to permit this line of analysis.
4. Alternative analyses considered

In this section my goal is to convince you that there is no other satisfactory way to analyze a language like Chamicuro.

There are four other possible ways to handle Chamicuro’s glottal consonants in terms of OT. Each one avoids the new constraint HAVEPLACE(ONSET). Nevertheless, I will argue that each of these four re-analyses is inferior and should be rejected.

(a) First, in Parker (1994) I posited a positional markedness filter prohibiting laryngeal feature specifications in onset position: *ONSET(LARYNGEAL). However, in that work I was crucially assuming a rule-based framework in which that mechanism was operational only in Chamicuro. Given the cross-linguistic consequences of factorial typology in OT, this is no longer feasible since it could lead to a pathological (unattested) language in which aspirates and/or ejectives occur only in coda position:

\[(19)\] hypothetical

<table>
<thead>
<tr>
<th>Input: /tʰapa/</th>
<th>*ONSET(LARYNGEAL)</th>
<th>IDENTLARYNGEAL</th>
<th>*LARYNGEAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [tʰapa]</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. [tapa]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[(20)\] hypothetical

<table>
<thead>
<tr>
<th>Input: /aθpa/</th>
<th>*ONSET(LARYNGEAL)</th>
<th>IDENTLARYNGEAL</th>
<th>*LARYNGEAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [aθpa]</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. [atpa]</td>
<td></td>
<td></td>
<td>*!</td>
</tr>
</tbody>
</table>

(b) Second, in Parker (1989) I posited that /h/ and /θ/ are higher in sonority than all other consonants in Chamicuro. I then argued, based on Clements’ (1990) Sonority Dispersion Principle, that there is a threshold effect on onsets in Chamicuro such that segments of very high sonority are disallowed in this position and preferred in codas. Similar proposals are made in Macaulay and Salmons (1995), Bernhardt and Stemberger (1998), and de Lacy (2002). However, this is controversial since it claims that /θ/ and /h/ can be higher in relative sonority than the voiced oral glides /w/ and /y/. Given this anomaly, I no longer pursue this analysis.

(c) Third, Howe and Pulleyblank (2001) posit positional faithfulness constraints like MAX[CG]-μ, which preserves the feature [constricted glottis] when dominated by a mora. However, this makes the same fatal typological mis-prediction as *ONSET(LARYNGEAL). The same would be true of a hypothetical “anti positional faithfulness” constraint like IDENTCODA(LARYNGEAL). Furthermore, a constraint requiring [cg] to be licensed by a mora begs the question, why should this feature in particular, rather than some other one like [voice], [strident], [nasal], etc., have to be dominated by a mora? Similarly to a brute-force constraint like hypothetical *ONSET/h,?, it observes the facts but does not explain in a principled and natural fashion why the patterns that do exist, should exist.
Fourth, Bernhardt and Stemberger (1998) propose a novel system of constraints which can accommodate languages like Chamicuro. However, certain aspects of their model are problematic on both theoretical and typological grounds. The four constraints they would use, and their ranking, are as follows. Each one is “translated” into a more familiar equivalent:

(21) **SURVIVED(C-PLACE):** A Consonantal-Place Node in the underlying representation must be present in the output. (≡ MAX(PLACE))

   >>

**NOTCO-OCCURRING(RHYME,C-PLACE):** Rhyme and Consonantal-Place may not co-occur at the same point in time. (≡ *CODA(PLACE))

   >>

**CO-OCCURRING(σ-Margin→C-PLACE):** Syllable margins must co-occur with (must contain) a Consonantal-Place node. (≡ HAVEPLACE(ONSET&CODA))

   >>

**NOT(C-PLACE):** A Consonantal-Place node must not appear in the output. (≡ *PLACE)

The following abbreviated tableaux show the evaluation of the same two Chamicuro input forms as before (the second of which is hypothetical), using the Bernhardt and Stemberger (1998) system just outlined:

(22)

<table>
<thead>
<tr>
<th>Input: /nihpa/</th>
<th>SURV(CPL)</th>
<th>NOTCO(RH,CPL)</th>
<th>CO(σ-M→CPL)</th>
<th>NOT(CPL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ef [nih.p]</td>
<td></td>
<td></td>
<td>*</td>
<td>**</td>
</tr>
<tr>
<td>b. [niš.p]</td>
<td></td>
<td>*!</td>
<td></td>
<td>***</td>
</tr>
</tbody>
</table>

(23) hypothetical

<table>
<thead>
<tr>
<th>Input: /nihapa/</th>
<th>SURV(CPL)</th>
<th>NOTCO(RH,CPL)</th>
<th>CO(σ-M→CPL)</th>
<th>NOT(CPL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [nihapa]</td>
<td></td>
<td></td>
<td>*!</td>
<td>**</td>
</tr>
<tr>
<td>b. ef [nišapa]</td>
<td></td>
<td></td>
<td></td>
<td>***</td>
</tr>
</tbody>
</table>

We thus see that the Bernhardt and Stemberger (1998) model allows us to derive languages like Chamicuro but with different constraints. Nevertheless, there are two main problems with this approach:

(a) The introduction of the rhyme constituent as a primitive argument which can be targeted by constraints extends “positional faithfulness” types of behavior to coda consonants. However, this allows CON to generate a language in which the entire inventory of coda consonants is limited to
voiceless stops and nothing else (Bernhardt and Stemberger 1998:214ff). Since no systems of this type are attested in adult languages, the factorial typology permitted by this model is too powerful. This theory therefore encounters empirical problems with the basic facts of the universal onset/coda asymmetry, a central topic of this paper.

(b) The second drawback with this approach is that it employs faithfulness constraints of the SURVIVED(FEATURE) variety (which are analogous to (MAX(FEATURE))) rather than IDENT(FEATURE). The problem is that IDENT(FEATURE) constraints achieve featural stability in a much more compact way. For every MAX(FEATURE) constraint which prohibits deletion of an underlying feature, two other corresponding constraints are required: DEP(FEATURE) to prevent insertion of that feature, and NOFLOP(FEATURE) to block it from shifting to a different segmental anchor. Bernhardt and Stemberger (1998:169) acknowledge their concern about this proliferation of formal devices and note that some cases of deletion are captured more elegantly by IDENT. They thus concede that both SURVIVED and IDENT are required in their model, which is therefore “technically inadequate” (p. 680).

In conclusion, the theoretical underpinnings of the model of CON which I assume are much more restrictive and hence preferable. Consequently, introducing a single (partially) new constraint (HAVEPLACE(ONSET)) causes less disruption to classical OT in the long run (cf. Pater 1999).

5. Extending the analysis

With respect to the inventory of consonants permitted in coda position, there is a continuum of four main types of languages:

(24)  a. No codas at all.
     b. Placeless codas only.
     c. Coda and onset inventories basically identical.
     d. Coda inventory same as onset inventory plus laryngeals. (= Chamicuro)

The other three types of languages can be generated as follows:

(a): No codas whatsoever.

examples: Maori (New Zealand: Bauer 1993), Rotokas (PNG: Firchow and Firchow 1969)

-crucial rankings:  NOCODA \succ FAITH

-effects (ceteris paribus): All underlying coda consonants are forced to delete or are repaired by inserting a vowel.

(b): Only placeless codas are allowed.

-example: Bora (Peru: Thiesen and Thiesen 1975)

-crucial rankings:  IDENTONSET(PLACE) \succ *PLACE \succ IDENT(PLACE)
effects: All onset consonants must surface unchanged, even if they have a supralaryngeal place specification. Underlying coda consonants must undergo debuccalization and surface as either [h] or [ʔ].

(c): (Virtually) all consonants which occur in onset position may also appear in codas.

effect: All consonants surface completely unchanged, regardless of their position in the syllable.

crucial rankings: FAITH >> NoCoda

6. Conclusion

In this paper I have examined the very striking but firm restriction of glottal consonants to syllable-final position in Chamicuro and similar languages. To account for this pattern I have posited another positional markedness constraint, HAVEPLACE(ONSET). This innovation constitutes a very logical, benign, and restrictive expansion of a previous constraint which is phonetically grounded in the notion of segmental release.

An obvious question at this point is, why are such languages so rare? Having listened to the Chamicuro language long enough, I can attest that syllable-final laryngeal consonants are hard to hear (and it’s often difficult to distinguish /h/ from /ʔ/ in this position). I think this is because the lack of an audible release makes the acoustic cues harder to perceive.

A significant theoretical repercussion of my account is that it allows us to maintain the positional faithfulness insight that the syllable onset is one of the prominent domains which is “privileged” vis-à-vis the coda. Likewise, Goldsmith’s (1990) view of the onset node as a strong “licensor” is not only retained, but actually reinforced in a certain sense: just as there is a cross-linguistic tendency for placeless segments to prefer codas over onsets, so there is a corresponding pressure for consonants in onset position to optimally exhibit a salient contrast for place of articulation. This predicts (correctly I think) that only placeless segments like glottal consonants should in principle be able to exhibit the type of exceptional distribution observed in Chamicuro. In summary, while the onset/coda asymmetry has now been falsified at the segmental level, it still holds true at a natural class level, in the following sense: in any given language, onsets and codas may permit the same contrasts for place of articulation, or onsets may permit a greater number of distinctive place of articulation features, but there is no language which allows more place node contrasts in syllable-final position than in onsets.

References


Howe, Darin, and Douglas Pulleyblank. 2001. “Patterns and timing of glottalisation.” *Phonology* 18:45-80.


theory, optimality, and universal grammar in cognitive science. Available from the Rutgers Optimality Archive as ROA 428.

University of Massachusetts Amherst: Graduate Linguistic Student Association.


Dear Mom and Dad:

I know you worry about me a lot since I'm out here in the jungle, but as I've assured you before, I'm really in a quite pleasant and safe environment. Just to put your imaginative minds at ease, I've compiled some typical scenes from my everyday life to show you what the conditions here are like.

The Men's Dorm, where many of the bachelors on our center live, is often referred to as the Home for Unwed Boys (HUB). There we prepare exquisite native foods and keep the house in the most tidy of conditions. As you can see in this first picture, it was my turn one week to prepare breakfast for all of us guys.

The founder and president of the HUB is my close friend and associate Owen Blickensderfer. In this next shot you can see him playing with one of the many house pets we like to keep around.
We often find that after a hard day's work, the surrounding vegetation has grown so much that we have to discover a new route to get home. The big, strong, handsome chap you see helping me is the famous pioneer missionary trailblazer, Jeff Scott.

The food here is quite nourishing. On days when we can't think of anything else to fix, we usually fall back on our hearty recipe for stew.

To get our daily exercise, we often go down to the lake for a refreshing afternoon swim. Here you see Owen enjoying himself at the old swimming hole.