Introduction

Laryngeal co-occurrence restrictions are widely attested within roots.
(e.g. Itô & Mester 1986, MacEachern 1999, Rose & Walker 2004, Hansson 2010, Gallagher 2010b, Rose 2011, W. G. Bennett 2015, etc.)

(1) Chaha: ejectives don’t occur with plain voiceless stops in roots
(Rose & Walker 2004, Rose & King 2007, Gallagher 2010a)
  a. [ji-kɔft] ‘he opens’
  b. [ji-t’ɔβk?] ‘it is tight’
  c. *[ji-kɔft]
  d. *[ji-kɔft’]

Laryngeal co-occurrence restrictions in Kaqchikel roots

Kaqchikel has a phonemic contrast between plain voiceless and ‘glottalized’ plosives at corresponding places of articulation.

<table>
<thead>
<tr>
<th></th>
<th>Bilabial</th>
<th>Dental/Alveolar</th>
<th>Post-Alveolar</th>
<th>Velar</th>
<th>Uvular</th>
<th>Glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop</td>
<td>p</td>
<td>b</td>
<td>t</td>
<td>t’</td>
<td>k’</td>
<td>q’</td>
</tr>
<tr>
<td>Affricate</td>
<td>ñts</td>
<td>ñts’</td>
<td>tj’</td>
<td>tj’’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(2) a. /koχ/ ‘lion’
    b. /k’ɔχ/ ‘mask’
(3) a. /w-aq/ ‘my pig’
    b. /w-aq’/ ‘my tongue’

Multiple ejectives are not allowed in a /CVC/ root, unless they are identical (Edmonson 1988: 60-72, R. Bennett to appear, and references there)

\[ */T_1^2VT_2^2/, 1 \neq 2 \]

(4) a. /t^2'ot^2/ 'snail'
    b. /k^2'ek^2/ 'stingy'
    c. /q^2'aq^2/ 'fire'
    d. /tj^2'ij^2/ 'metal'

(5) a. */q^2'ot^2/
    b. */k^2'eq^2/
    c. */q^2'atj^2/

Plain stops are unrestricted.

The labial implosive /b/ and glottal stop /ʔ/ are exempt from this restriction, and freely combine with ejectives in /CVC/ roots.

(6) /b/ exempt
a. /b^2'is/ 'thread'
b. /k^2'i\tilde{b}/ 'pacaya (fruit of the Chamaedorea palm)'
c. /-\tilde{b}iq/ 'to swallow'

(7) /ʔ/ exempt
a. /t^2's\tilde{i}/ 'dog'
b. /ik^2/ 'moon' (surface [Pik^2])
c. /q^2'uʔ/ 'blanket'

Analytical problem: [constricted glottis] alone does not pick out the correct natural classes for Kaqchikel.

▶ /T^q/ are [CG].
▶ /b ?/ are [CG] too.

Phonetic realism

Auditory similarity is expressed with **acoustically-defined phonological features**.

Features relevant for ejectives:

- **Burst intensity**: [LOUD BURST]
- **Release duration**: [LONG VOT]
- **Phonation**: [CREAK]

These are **redundant** features: not independently contrastive, but predictable phonetic properties of ejectives.

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Phonetic realism

The acoustic properties of ejectives vary widely across languages.

- **Consequence**: the featural representation of ejectives must also vary across languages. ([Gallagher 2010b: 38])
  - **Cochabamba Quechua**: /T\ ^= [LOUD BURST, LONG VOT]
  - **Hausa**: /T\ ^= [CREAK]


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Phonetic realism

**Claim**: laryngeal co-occurrence restrictions are stated over these redundant, language-specific auditory properties.


\[8\] **OCP[LOUD BURST]**: Roots cannot contain two instances of a stop specified (redundantly) as [LOUD BURST]. ([Gallagher 2011])

This is **phonetic realism**: Language-specific **phonetics determine language-specific phonotactic patterning**.

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**Prediction**

Segment classes in laryngeal co-occurrence restrictions should correspond to phonetic classes defined by acoustic/auditory similarity.
Results

**Phonetic realism:** some auditory feature should be *unique* to ejectives (the restricted class).

**Finding:** no acoustic property is unique to ejectives.
- Burst intensity and VOT: /T/ $\approx$ /$T^2$/
- Phonation: /$\delta$/ $\approx$ /$T^2$/

(Note: our presentation is informal/visual, but all of our descriptive claims are backed-up by statistical clustering techniques and mixed-effects regressions.)

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### Ejectives across languages:

<table>
<thead>
<tr>
<th></th>
<th>Stiff</th>
<th>Slack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burst intensity</td>
<td>Loud</td>
<td>Weak</td>
</tr>
<tr>
<td>Release duration</td>
<td>Long</td>
<td>Short</td>
</tr>
<tr>
<td>Phonation</td>
<td>Modal/tense</td>
<td>Creaky</td>
</tr>
</tbody>
</table>


**Observation:** ejectives appear to be slack in Kaqchikel.
- Release properties (burst, VOT) much like plain counterparts.
- Creakiness distinguishes ejectives from plain counterparts.

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### Slack ejective [k$^2$] in Kaqchikel

*kan tzij k’a ri* /kan tsiX k?a ri/ *(but it was) truly like that* (speaker 8)
**LOUD BURST**

Peak intensity (first 25ms after release)

- /p b/ (n=304, n=326)
- /t tˀ/ (n=867, n=15)
- /ts tsˀ/ (n=214, n=121)
- /tʃ tʃˀ/ (n=679, n=69)
- /k kˀ/ (n=1014, n=562)
- /q qˀ/ (n=714, n=152)

Peak intensity during burst (first 25ms of VOT interval)

(Blumstein & Stevens 1979, Stevens 2000: 455)

**LONG VOT**

VOT values

- /p b/ (n=322, n=328)
- /t tˀ/ (n=886, n=16)
- /ts tsˀ/ (n=214, n=121)
- /tʃ tʃˀ/ (n=681, n=69)
- /k kˀ/ (n=1028, n=560)
- /q qˀ/ (n=713, n=153)

VOT (release noise) duration

VOT does not reliably separate plain and ejective stops (except /k kˀ/).
None of the Kaqchikel ejectives merit the label [LONG VOT].

(See also Keating 1984, Cho & Ladefoged 1999, Holt et al. 2004.)

- Mean VOTs for /Tʰ/: 24-46ms

VOT values in Cochabamba Quechua (Gallagher 2011)

A standard measure of voice quality is H1-H2:

- Relative amplitude of f0 (H1) and the second harmonic (H2).
- Low H1-H2 ≈ more creak.

Phonation fails to distinguish /i/ from /Tʰ/.

- All glottalized consonants induce creaky phonation on adjacent vowels.
- Plain stops do not induce creaky phonation.
- (n = 4267 distinct stop-adjacent vowels)

Creakiness (H1*-H2*) during last 1/3 of vowel in VC transition
Interim summary

The acoustic features [loud burst, long VOT, creak] fail to define phonotactically appropriate natural classes.

- [loud burst, long VOT]: /T/ ≈ /T²/ (neither qualify)
- [creak]: /6/ ≈ /T²/

Conclusion: laryngeal co-occurrence restrictions in Kaqchikel cannot be stated over auditorily-defined features.

Formal analysis

Proposal: assume a different representational status for [constricted glottis] in /T²/ vs. /6 ?/

Assumption: stops have sub-segmental phonological structure.


Formal analysis

Stop

Closure Release

\{
\begin{align*}
\text{voice} \\
\text{CG}
\end{align*}
\}

Formal analysis

Implosives and /ʔ/

Stop

Closure Release

\{
\begin{align*}
\text{CG}
\end{align*}
\}

Ejectives

Stop

Closure Release

\{
\begin{align*}
\text{CG}
\end{align*}
\}

The restriction, restated

Assign one violation for every /CVC/ root containing two instances of Release-linked [Constricted Glottis].

(NB: the permissibility of co-occurring identical ejectives requires further mechanisms; McCarthy 1979, 1989, Gallagher & Coon 2009, Gallagher 2010a, 2014, etc.)

Formal analysis

Predicted long-distance dissimilations:
- OCP[voi]: Voiced obstruents (∧, Japanese, Itô & Mester 1986)
- OCP[cg]: Ejectives, implosives and /ʔ/ (∧, Bolivian Aymara, Landerman 1994)
- OCP[sg]: Aspirated stops and /h fi/ (∧, Sanskrit, Grassmann 1863)

Formal analysis

Unexpected long-distance dissimilations:
- Ejectives/aspirated stops and voiced stops (unattested)
- Aspirated stops and implosives (unattested)
Conclusion

With respect to root-level laryngeal co-occurrence restrictions in Mayan:

- Phonetic realism is too strict: phonotactic classes do not line up with acoustic classes in Kaqchikel (and probably other Mayan languages).
- A more promising tact: OCP constraints stated over abstract (but articulatorily-grounded) features in sub-segmental structure.

The distinction between ejectives and implosives is crucial for phonotactic patterning in Kaqchikel.

- The realization of the glottalized labial as implosive /ɓ/ (rather than ejective /p/) is predictable from its place of articulation.
- Predictable, redundant, and non-contrastive properties must be phonologically ‘active’ for the purposes of phonotactic restrictions.

References

References available on request.

Slide download

Slides available for download at http://tang-kevin.github.io/Files/Slides/Bennett_Tang_AMP.pdf