Ejective Reduction in Chaha is Conditioned by
More Than Prosodic Position

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Abstract
This paper examines a neutralization asymmetry in Chaha ejectives, concluding that reduction is conditioned not by prosodic position alone, but also by place and manner of articulation. An acoustic examination of Chaha, a Gurage dialect of the Ethiopian Semitic language family, shows that its velar ejectives display a much stronger tendency to lose burst cues before another ejective than do alveolar ejectives in the same environment. This pattern of laryngeal neutralization provides important support for phonetically informed phonological theories. Purely prosody-based theories cannot account for this behavior but a viable alternative is found in a cue-based approach.

1. Introduction
Chaha ejective clusters such as those given below exhibit a pattern of reduction that is asymmetrical.

(1) [nık’t’ir] 1sg jussive “kill”
(2) [nîıt’.k’ir] 1sg jussive “hide/store”

Although the ejectives (the first in each cluster is of interest, shown here in bold) are in identical environments with respect to prosody (i.e., in coda position), they are realized differently; there is a statistically significant difference from the norm in the duration of the bursts of these consonants. The duration of the velar ejective’s burst before another ejective such as in (1) is almost always reduced to zero or near zero (a short faint artifact is sometimes visible on the spectrogram as the oral closure is moved from velar to alveolar). The alveolar burst in a word like (2), by contrast, is not significantly shorter than when that segment is in other positions. This is not simply a difference between velar consonants and alveolars with respect to burst duration: when [k’t’] sequences are compared to all other possible [k’____] sequences, including [k’t] (identical except for laryngeal specification) the former is found to differ significantly from all the rest. The analogous claim does not hold for alveolar ejectives. First, velar and alveolar consonants are examined in different environments in Chaha words to determine whether the asymmetry correlates with a laryngeal feature (namely ejective nature, it has implications for phonological models. The cue-based approach incorporates facts about perceptual salience as its basis for explanation of phonological phenomena. Such a model provides a more explanatory account of the common range of cross-linguistic patterns and also gives greater insight into why asymmetries such as the one found in Chaha might arise.

1.1. Velars
Since the reduction found in Chaha takes place in velar segments only, it is necessary to examine the cross-linguistic sound change tendencies of velars. Velar segments can change by many processes, including debuccalization, voicing, spirantization, deglottalization and devoicing. Often these changes are some type of lenition, but not always.

Velars are particularly prone to sound change. Rose (1999) reports that in Muher, a Gurage language closely related to Chaha, singleton ejective velars undergo lenition post-vocally in the form of debuccalization to [ʔ] [1]. Muher also has velar spirantization, which is lexicalized but historically was conditioned. Alan Yu (1999) reviewed cross-linguistic spirantization patterns and found that velars and uvulars were the most likely to undergo spirantization – approximately three-quarters of the attested patterns involve velars/uvulars [2].

Although these examples of lenition show different processes from the neutralization found in Chaha, they are related in the sense that they show that velars have certain inherent strengths and weaknesses. They have strong place cues, especially salient in the formant transitions they produce on neighboring vowels. Their bursts, however, tend not to be so robust. Debuccalization preserves the identity of the ejective velars as back as well as preserving the feature constricted glottis – the only thing they lack is the velar burst. The spirantization data illustrates that velars are more prone to change of manner than other places of articulation are because of velars’ poor cues to manner (i.e., their bursts). The proposal in §3 explains the tendency of velars to be misperceived and therefore reanalyzed (and thus the strong tendency of velars to undergo sound changes mentioned above) by considering the articulatory constraints on producing perceptible cues for velars in certain environments.

1.2. Distribution of Ejectives in Chaha
In Chaha, there is a three-way contrast between consonants of a given place. Labial consonants do exist, but
the labial ejective is found only in borrowed words, and is rare. Likewise, the pulmonic [p] appears as an allophone of [β] in highly specific contexts or in borrowed words [3]. Therefore I do not consider labials in this study. Velar, alveolar, and post-alveolar consonants may be voiced ([g], [d], [dʒ]), voiceless ([k], [t], [ʈ]) or ejective ([k’], [t’], [ʈ’]). Unlike in some languages, there does not seem to be any restriction on the number of ejectives a word may contain:

Ejectives are separate phonemes from their voiceless aspirated counterparts, as illustrated by the minimal pair [tf’/anam] he’fti gave birth, and [tʃanam] he’fti came.

In Chaha, syllables may be closed, but coda clusters are not allowed, except word-finally. The onset may have certain obstruent-r clusters such as [tr], but some speakers do not even tolerate these and epenthsize vowels. All the medial ejective clusters referred to in this paper are therefore coda-onset sequences.

There is a Morpheme Structure Constraint on stops in verb roots, as Banksira states: “[…] Adjacent stops in a root may not differ in laryngeal specification. For instance, adjacent ejective stops are found in a root and so are adjacent voiced stops. […] No native root contains an ejective-voiced or voiced-ejective stop sequence….”

Note that native speakers still identify unreleased consonants in clusters as ejectives, despite the lack of release cues to ejetiveness. This is probably a side-effect of the MSCs mentioned above. Words with mixed clusters such as /ktʃit/’ or /kʃtʃtʃ/ are simply not possible in Chaha because they mix ejective and voiced consonants in a single root. Thus, even if one consonant of a verb root is unreleased, there can be no confusion about phonemic identity if any other segment is ejective.

2. Study Results

Chaha’s asymmetry of /k’/t/’ and /t’/k/’ is particularly interesting because of the factors that condition it, namely place and airstream mechanism. An asymmetry of this type cannot be described or predicted by a theory that cites prosodic position as the conditioning factor for neutralization of laryngeal features. If laryngeal neutralization were predicted to occur in coda position, it should also apply to [t’/k’] clusters, which do not, in fact, lose their laryngeal distinctions in Chaha. While it is true that coda position is undoubtedly a factor in conditioning laryngeal neutralization, the strictly position-based theory cannot account for these data. There is a deeper factor present in coda position that would be a more accurate way to characterize the environment that favors laryngeal neutralization. At the end of the next section such a theory is presented and adapted to these data, after demonstrating that prosodic theories cannot account for the Chaha asymmetry.

The focus of Fig. 1 is the cluster /k’/t/’, the second column from the left, shown in contrast. This demonstrates that the velar ejective patterns differently than its alveolar counterpart.

3. The Asymmetry and Phonological Theory

3.1. Licensing by Prosodic Position

Using a prosodic licensing approach to account for our Chaha data would require that we resyllabify [t’/k’] as a complex onset while leaving [k’/t’] heterosyllabic in order to explain the data. Such an approach is not independently motivated, and moreover would violate the overall syllable structure of Chaha. Alternately, a coda neutralization rule might be formulated such that it only applies to velars. This approach would describe the data, albeit by stipulation. Its shortcoming is in the area of explanation. Such an analysis would offer the insight that velars pattern differently, but offers no reason for why they diverge from the norm.

Thus, these solutions are not satisfactory; although they are driven by these data, they are neither motivated by other language internal data, nor by cross-linguistic data.

Lombardi uses Optimality theory (OT) to account for syllable-final laryngeal neutralization in German [5]. She posits two constraints on the faithfulness of the output to the underlying form. They differ only in position, crucial for the account of how laryngeal contrasts are maintained in onset position but neutralized in codas. Lombardi’s positional faithfulness constraints are as follows:

IDentOnset(Laryngeal) (abbreviated IDOnsLar):
Consonants in the position stated in the Laryngeal Constraint should be faithful to underlying laryngeal specification.
IDent(Laryngeal) (IDLar)
Consonants should be faithful to underlying laryngeal specification.

It is noteworthy that the duration of the [t’] burst when followed by [k’] is not significantly different from its duration in other environments, even onset/prevocalic environments. (You may wonder about the geminate [tt] in this graph: it has no burst.)

Furthermore, a velar ejective’s burst is significantly shorter when followed by the ejective alveolar than if it is followed by the pulmonic alveolar, illustrated in the second and first columns of Fig. 1, respectively. There is a statistically significant difference between the duration of the burst for an ejective velar before an ejective alveolar and the duration of the burst of the same consonant before a pulmonic alveolar – in other words [k’t] compared with [k’t] (F(1, 62), p < 0.0002). This significant quantitative difference occurs despite identical prosodic positions and oral gestural sequences. Such a dramatic asymmetry in burst duration was not found for any other cluster.

Figure 1: Burst Durations of All Available
Voiceless Stop-Stop Clusters

Mean Duration of 1st Consonant
(in msec.)
These constraints are balanced by the markedness of laryngeal features, formalized below:

*LAR: do not have laryngeal features.

The simple interaction of these ranked constraints is shown in the tables below.

<table>
<thead>
<tr>
<th>/rad/</th>
<th>IDOnsLar</th>
<th>*Lar</th>
<th>IDLar</th>
</tr>
</thead>
<tbody>
<tr>
<td>rad</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>*# rat</td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>/rades/</th>
<th>IDOnsLar</th>
<th>*Lar</th>
<th>IDLar</th>
</tr>
</thead>
<tbody>
<tr>
<td>*# ra.des</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>ra.tes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An attempt to apply this approach to the Chaha asymmetry has the same problems as previous attempts, because it uses the same prosodic basis. The ranking for German works to give us the velar-alveolar sequence neutralization, as can be seen by the tableau for the Chaha word “let me kill.”

<table>
<thead>
<tr>
<th>/nik’t’ir/</th>
<th>IDOnsLar</th>
<th>*Lar</th>
<th>IDLar</th>
</tr>
</thead>
<tbody>
<tr>
<td>nik’t’ir</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*# nik’t’ir</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

However, the alveolar-velar sequence crucially relies on the constraint “Lar being ranked below IDLar as seen below for “let me hide/store.”

<table>
<thead>
<tr>
<th>/nit’k’ir/</th>
<th>IDOnsLar</th>
<th>*Lar</th>
<th>IDLar</th>
</tr>
</thead>
<tbody>
<tr>
<td>*# nit’k’ir</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>nit’k’ir</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In this case, the constraint IDLar would have to be further split into IDAlvLar and IDAvLar, which would be crucially ranked: IDAlvLar >> *Lar >> IDAvLar. So again we find that a prosodic licensing account of the Chaha data forces us into stipulations. Although this approach can be forced to work, like the stipulation of a velar domain we rejected in the earlier rule-based prosodic licensing approach, this constraint-split does not explain the asymmetry, it merely describes it.

### 3.2. Licensing by Cue

Licensing by cue addresses the fact that neutralization occurs when availability of cues is poor – for example, in coda position, burst cues tend to be obscured (perceptually) and reduced (articulatorily) [5]. That tendency is the cause of neutralization in coda position, a fact that is made explicit by a cue-based approach.

Steriade (1997) illustrates the relevance of the timing of glottal and oral gestures to patterns of neutralization to the availability of laryngeal cues. The cue availability and timing of oral events relative to glottal events differs for glottalized sonorants and ejectives, for example, which results in different patterns of laryngeal neutralization. Ejectives, whose cues to glottalization are at the release of the segment, occur in any position or sequence without being neutralized, while sonorants, whose cues to glottalization occur at the onset of the segment, are neutralized unless they are preceded by a vowel or another sonorant.

To formalize the correlation between cue availability and context, Steriade makes explicit the relationship between cue-availability and gestural timing. There are two types of cues to laryngeal features: (1) Internal cues occur during the period of oral constriction of a segment, and (2) transitional (or contextual) cues occur outside the period of oral constriction. Transitional cues are relevant to the process of neutralization.

Transitional cues to laryngeal features can reside at the onset or the release of a segment. Aspiration, for example, can occur in either of those two places on a stop, yielding preaspirated or post-aspirated stops. If the laryngeal feature begins before the accommodating oral constriction, the context preceding the segment will be most influential for neutralization of the laryngeal feature, since that is where the transitional cues to its presence will occur. In such cases, the context preceding the segment will determine whether the laryngeal feature is neutralized. Alternatively, if the laryngeal feature continues after the accompanying oral constriction ends, the context following the segment will be most influential for neutralization of the laryngeal feature, since that is where the transitional cues to its presence will occur. In these cases, the context following the segment will determine whether the laryngeal feature is neutralized.

The glottal gesture for an ejective consonant is constriction, sealing the glottis and stopping airflow across it. When an ejective is followed by a vowel, the constriction is followed by adduction, allowing air to pass across the vocal cords and produce voicing. Additionally, during the stop closure, the larynx raises to pressurize the oral cavity. Oral gestures are executed simultaneously with the glottal and laryngeal gestures.

#### 3.2.1. A cue-based account of Chaha

The hypothesis I sketch in this section is an articulatory explanation for the asymmetry between [t’] and [k’] in Chaha clusters. I suggest that coarticulation plays a role in this case, as it is known to do in many other phenomena, such as the epenthesis of oral stops between a nasal stop and oral consonant (i.e., in the English word “warmth.” /…mθ/ becomes […]mpθ] when the oral closure of the nasal stop persists after the velum has changed position to allow the fricative to take place)[6]. In an ejective stop cluster [C1, C2], if the (oral) release of C1 and the (oral) closure of C2 overlap, place of articulation becomes crucial. The chart below summarizes the relevant cue availability and phonetic realization:

<table>
<thead>
<tr>
<th>place cues:</th>
<th>[+son] t’ k’</th>
<th>[+son] k’ t’</th>
</tr>
</thead>
<tbody>
<tr>
<td>place preserved?</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>ejective cues:</td>
<td>burst</td>
<td>burst reduced or ø</td>
</tr>
<tr>
<td>realized as ejective?:</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

Table 3: Phonetic cue availability for /t’k’/ and /k’t’/ clusters

If the place of C1 is farther back than that of C2, pressure considerations as well as overlap will tend to affect (reduce and obscure, respectively) any release burst of C1. If, on the other hand, C1 is farther forward than C2, it will be released despite overlap with the C2 closure behind it since that back closure will fail to affect the resonating chamber anterior to the C1 closure (labeled b in the diagram below).
Figures 3-4: Alveolar and Velar Oral Gestures

Fig. 3 [t’]

Fig. 4 [k’]

Fig. 5

Figure 5: Interference between Alveolar and Velar closures
If a velar closure interrupts an alveolar burst (i.e., the sequence is [t’k’]), the only consequence for [t’] is that the source is cut off, while if the sequence is reversed, the flow from the resonating cavity is damped, having serious repercussions for the perceptibility of burst cues.

Theories based on prosodic licensing cannot explain this pattern, despite the fact that it likely shares a common cause with the phonologized patterns (but shows them in a phonologically immature state). This is because they do not assign responsibility for neutralization patterns to what appears to be their source – the availability of phonetic cues to the contrast. The price of the abstract nature of strictly prosodic theories is that it can lead to difficulties in describing patterns and a lack of cross-linguistic unity in explaining them. A cue-based approach to licensing not only brings to light the cross-linguistic propensity of laryngeal neutralization to occur in coda position as well as the phonetic asymmetry found in Chaha, but also reveals the motivation for these patterns.

4. Conclusions

This asymmetry provides support for choosing a cue-based licensing approach over a prosody-based licensing approach. Most phonological work on laryngeal neutralization defines the environment in which it occurs in terms of syllabic position rather than a combination of position, place and manner, as seems to be the case in Chaha. The fact that segments in identical prosodic positions can have different patterns of laryngeal neutralization argues against prosody-based theories. Additionally, the pattern of the phonetic realization of ejective clusters has been shown to correlate with cue availability considerations, which suggests that a cue-based licensing approach is an improvement in explanatory adequacy.

Though these Chaha results are phonetic, and have not impacted the phonology of Chaha, it is easy to imagine a scenario in which it might be possible for the asymmetry finding to become relevant to a phonological system. For example, were the phonological restrictions on ejective harmony within roots (that all root stops of a verb must agree in ejectiveness) relaxed, then we might find that this phonetic phenomenon could become phonologically significant. In other words, this could diachronically contribute to neutralization. A phonological theory that also has the ability to capture such phenomena is valuable because of its ability to model sound change as well as stable sound systems. The evidence provided by Chaha offer support for licensing by cue. Prosodic licensing accounts, in light of phonetic evidence, appear to have less explanatory power.

5. References