Classifying Apurímac Quechua Ejectives

Mackenzie Marcinko
University of Delaware

Follow this and additional works at: https://repository.upenn.edu/pwpl

Recommended Citation
Available at: https://repository.upenn.edu/pwpl(vol27/iss1/18

This paper is posted at ScholarlyCommons. https://repository.upenn.edu/pwpl(vol27/iss1/18
For more information, please contact repository@pobox.upenn.edu.
Classifying Apurímac Quechua Ejectives

Abstract
I analyze ejective stops in Apurímac Quechua (a variety of Quechua spoken in Southern Peru) in light of the classification system proposed in Lindau (1984) and Kingston (1985), in which ejectives are considered strong or weak based on their acoustic properties. I discuss quantitative characteristics of Apurímac Quechua ejectives as determined in an acoustic study and evaluate the suitability of Lindau (1984) and Kingston (1985)’s typology for categorizing ejectives in light of the Apurímac Quechua data, considered holistically along with data on ejectives from other languages.
Classifying Apurímac Quechua Ejectives

Mackenzie Marcinko*

1 Introduction

This paper examines acoustic characteristics of Apurímac Quechua ejectives in light of a dichotomous classification system which labels ejectives weak or strong based on their acoustic characteristics (Lindau 1984, Kingston 1985, Wright et al. 2002). The paper assesses the suitability of this classification system based on the acoustic characteristics of Apurímac Quechua ejectives, examined together with data on ejectives from other languages.

The paper is structured as follows: Section 2 contains an introduction to Apurímac Quechua ejectives, as well as a background on the strong-weak system of classifying ejectives. Section 3 details the methods of data collection and results from the acoustic study on Apurímac Quechua ejectives. Section 4 evaluates the suitability of the strong-weak system to categorize ejectives from Apurímac Quechua and several other languages, discussing alternatives to this classification system. Section 5 concludes.

2 Background

2.1 Apurímac Quechua Ejectives

Apurímac Quechua is spoken in Southern Peru (ISO 639-3: QEA) (Hammarström and Haspelmath 2018). There are no complete grammars of Apurímac Quechua apart from Camacho (2006)’s pedagogical description. The current paper is based on extensive work with one native speaker, Jermani, over the course of one year.

Apurímac Quechua, along with related varieties spoken elsewhere in Southern Peru and in Bolivia (e.g., Cusco Quechua and Cochabamba Quechua varieties) contain phonemic ejective stops at the bilabial, alveolar, velar, and uvular places of articulation (Adelaar 2004). Unlike Bolivian and other Southern Peruvian Quechua varieties, which contain a 3-way contrast between pulmonic unaspirated, pulmonic aspirated, and ejective voiceless stops, Apurímac Quechua has a 2-way contrast between pulmonic unaspirated and ejective voiceless stops (Adelaar 2004, Torero 1964). The Apurímac Quechua stop inventory is shown in Table 1. The present paper adopts the term pulmonic when referring to the pulmonic unaspirated stops shown below.

<table>
<thead>
<tr>
<th>Pulmonic unaspirated</th>
<th>Bilabial</th>
<th>Alveolar</th>
<th>Velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ejective</td>
<td>p’</td>
<td>t’</td>
<td>k’</td>
</tr>
</tbody>
</table>

Table 1: Apurímac Quechua stop phonemes.

2.2 Typology of Strong and Weak Ejectives

An ejective stop begins with closures of both the glottis and at the oral cavity (e.g. a closure at the lips) unlike pulmonic stops, which begin with only a single closure at the oral cavity. Pressure builds in the oral cavity, and as the closure is released, air flows out of the mouth, lowering the pressure in the oral cavity. Next, the larynx is raised. Higher pressure in the oral cavity builds as the larynx is raised and both closures are maintained. The oral closure is then released, and air rushes out of the mouth. The glottal closure is released at some point after the oral closure (Warner 1996). A second glottal closure and higher pressure in the oral cavity are the key features distinguishing ejective from pulmonic consonants (Warner 1996, McDonough and Ladefoged 1993).

There is substantial cross-linguistic variation in the acoustic features of ejective stops. Lindau

---

* This study would not be possible without Jermani Ojeda Ludeña, now at the University of Texas at Austin, who served as the language consultant during his year as a Fulbright scholar.
(1984) observed that Navajo and Hausa ejectives differ with regards to closure duration, total duration (closure duration plus voice onset time, abbreviated VOT) and voice quality in the beginning of the following vowel. Kingston (1985) proposed that vocal fold tension explains this variation, separating two categories of ejectives according to their acoustic properties and stiffness or slackness in the vocal folds. Wright et al. 2002 introduced the notions of strong (or stiff) and weak (or slack) with reference to these categories. Table 2 contains a list of common acoustic properties of strong and weak ejectives.

<table>
<thead>
<tr>
<th></th>
<th>Weak ejectives</th>
<th>Strong ejectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOT</td>
<td>short</td>
<td>long</td>
</tr>
<tr>
<td>Closure duration to VOT ratio</td>
<td>small</td>
<td>large</td>
</tr>
<tr>
<td>Total duration</td>
<td>short</td>
<td>long</td>
</tr>
<tr>
<td>Amplitude of following V</td>
<td>gradual to rise</td>
<td>quick to rise</td>
</tr>
<tr>
<td>F0 of following V onset</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>Voice quality of following V</td>
<td>creaky</td>
<td>modal</td>
</tr>
</tbody>
</table>


Strong ejectives involve glottal adduction through lengthwise tension and compression of the vocal folds. Strong ejectives have acoustic properties like a long VOT and powerful stop burst (Lindau 1984, Kingston 1985, Warner 1996). Strong ejectives also affect the following vowel, with vowels after strong ejectives quickly rising to maximum amplitude, and vowels after strong ejectives exhibiting a low F0 at the vowel onset or a falling F0 towards the vowel midpoint (Kingston 1985, Hargus 2007). Contrasted with strong ejectives are weak ejectives, which involve little longitudinal tension of the vocal folds. Weak ejectives are characterized by a shorter VOT and less-powerful stop burst than strong ejectives (Lindau 1984, Warner 1996). Vowels after weak ejectives rise to their maximum amplitude more slowly and have a creakier voice quality than vowels after strong ejectives. The F0 of vowels after weak ejectives is also said to be high at the onset or rise toward the vowel midpoint (Kingston 1985, Wright et al. 2002, Hargus 2007). Table 3 shows several acoustic characteristics of prototypically strong ejectives (Navajo: Lindau 1984, Tigrinya: Kingston 1985) and weak ejectives (Hausa: Lindau 1984, Quiche: Kingston 1985).

<table>
<thead>
<tr>
<th>Language</th>
<th>VOT</th>
<th>Closure duration to VOT ratio</th>
<th>Amplitude of following V</th>
<th>F0 of following V onset</th>
<th>Voice quality of following V</th>
<th>Strong or weak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navajo</td>
<td>long1 ~80ms</td>
<td>2</td>
<td>Quick to rise</td>
<td>-</td>
<td>modal</td>
<td>strong</td>
</tr>
<tr>
<td>Tigrinya</td>
<td>long ~80ms</td>
<td>-</td>
<td>Quick to rise</td>
<td>high</td>
<td>modal</td>
<td>strong</td>
</tr>
<tr>
<td>Hausa</td>
<td>short1 ~25ms</td>
<td>1.5</td>
<td>Gradual to rise</td>
<td>-</td>
<td>creaky</td>
<td>weak</td>
</tr>
<tr>
<td>Quiche</td>
<td>short ~50ms</td>
<td>-</td>
<td>Gradual to rise</td>
<td>low</td>
<td>creaky</td>
<td>weak</td>
</tr>
</tbody>
</table>


It is important to note that Lindau (1984) and Kingston (1985) compare acoustic properties of ejectives from one language to another. However, contemporary researchers (e.g., Warner 1996, Bird 2002, Ham 2004, Wright et al. 2002) often compare pulmonic stops within a given language to provide insight relative terms like short and long, which is an approach taken here.

1Kingston (1984) only provides mean total durations and the mean closure duration/VOT ratios. I examined waveforms in Kingston (1984) p. 154 to approximate VOT values of 80ms (Navajo) and 25ms (Hausa) in 10ms increments. These values also appear in Warner (1996).

2 - denotes an acoustic property not measured
Although the labels strong and weak are commonly used to categorize all the ejectives within a language, some research indicates that ejectives within a given language may be strong in one context but weak in another. For instance, word-initial ejectives are sometimes reported to be stronger than ejectives elsewhere in a word. Percival (2015) found that Déjine Slavey (Athabaskan) ejectives had longer VOTs word-initially than word-medially, meaning that Déjine Slavey ejectives are stronger word-initially than word-medially. Hul’q’umi’num’ (Salish) ejectives were found to have a longer total duration word-initially than word-medially, with vowels after word-initial ejectives also beginning with a higher F0 than after word-medial ejectives (Percival 2019). These results suggest that Hul’q’umi’num’ word-initial ejectives are stronger than word-medial ejectives with respect to duration and amplitude. On the other hand, vowels after word-initial ejectives in Hul’q’umi’num’ were creakie than vowels after word-medial ejectives, indicating that Hul’q’umi’num’ word-initial ejectives are weaker than word-medial ejectives with respect to phonation.

Morpheme structure and prosodic position have also been found to contribute to phonetic variation within a language’s ejectives. In Hän (Athabaskan), ejectives’ VOTs were longer on average in root stems than in prefixes, meaning that Hän ejectives tend to be stronger in stems than in prefixes (Manker 2012). Vicenik (2010) determined that higher prosodic positions are associated with ejective strengthening in Georgian: intonation phrase-initial ejectives had a longer closure duration, longer voicing lag and modal phonation when compared to accentual phrase-initial ejectives.

3 Acoustic Analysis

3.1 Stimuli and Procedure

The present acoustic study compared 3 Apurímac Quechua ejective stops /p̱, ṯ, ḵ/ with 3 pulmonic stops /p, t, k/. The uvular ejective /q̱/ was not included, because Apurímac Quechua lacks a pulmonic stop equivalent /q/. The 6 different stops were onsets to CV or C’V syllables, and the nucleus was always /a/. To ensure that each token of /a/ was able to be segmented in Praat easily, nasals and glides were never adjacent to /a/ (Boersma and Weeni 2019).

All syllables appeared within Apurímac Quechua words 3 syllables long. Given that word structure was shown to influence ejectives’ acoustic properties in Hul’q’umi’num’, target syllables appeared evenly throughout the words (in first syllable, second syllable, and third syllable positions). Apurímac Quechua words are also often heavily suffixed, so positioning target syllables across each word minimized any effects of morpheme structure on ejectives’ acoustic correlates, as determined in Hän (Manker 2012).

Table 4 shows the number of stops in each syllable condition and place of articulation, with example words from each condition. In total, 60 tokens in the first syllable position, 60 tokens in the second syllable position, and 30 tokens of the third syllable position were collected. Only pulmonic stops /p, t, k/ were present in the third syllable, because ejective stops never appear in the last syllable of Apurímac Quechua words. Of the 150 stops analyzed, 90 were pulmonic and 60 were ejectives.

---

3 As measured by H1-H2, the difference in amplitude between the first and second harmonics (Percival 2019).
4 Voicing lag is equivalent to positive VOT.
5 As measured by H1-H2 (Vicenik 2010)
<table>
<thead>
<tr>
<th></th>
<th>1st syllable position</th>
<th>2nd syllable position</th>
<th>3rd syllable position</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonic</td>
<td>10 bilabial pachata 'earth-ACC'</td>
<td>10 bilabial allpapi 'soil-LOC'</td>
<td>10 bilabial kachipa 'salt-GEN'</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>10 alveolar takata 'fist-ACC'</td>
<td>10 alveolar ataka 'foot, leg'</td>
<td>10 alveolar takata 'fist-ACC'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 velar kachipa 'salt-GEN'</td>
<td>10 velar takata 'fist-ACC'</td>
<td>10 velar ataka 'foot, leg'</td>
<td></td>
</tr>
<tr>
<td>Ejective</td>
<td>10 bilabial p'akina 'fragile'</td>
<td>10 bilabial hanp'atu 'toad'</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>10 alveolar t'akani 'scatter.1.SG'</td>
<td>10 alveolar llant'ata 'firewood-ACC'</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 velar k'akara 'crest, plume'</td>
<td>10 velar ruk'ata 'finger-ACC'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>60</td>
<td>30</td>
<td>150</td>
</tr>
</tbody>
</table>

Table 4: Number of words by place of articulation, word position, and stop type.

Each word was placed in two carrier dialogues representing two prosodic positions, appearing as the focused element in one dialogue, and the unfocused element in the other dialogue. The current study only addresses data collected from the focused position as seen in (1), because the comparison of acoustic properties between focused and unfocused elements is outside the scope of the current paper and will be addressed in the future (c.f. University of Delaware Prosodic Typologies Lab). In (1), tikata ‘flower-ACC’ in the answer statement is under prosodic focus.

(1) Imatataq Maria kutipa-ra-n kuna-m illariy-pi
What Maria repeat-PST-3.SG in-EV sunrise-LOC
‘What did Maria repeat in the morning?’
Maria tika-ta kutipa-ra-n kuna-m illariy-pi
Maria flower-ACC, repeat-PST-3.SG in-EV sunrise-LOC
‘Maria repeated “flower” in the morning.’

One native speaker of Apurímac Quechua (Jermani Ojeda Ludeña), a then 28 year old male born in the Abancay province of Peru’s Apurímac region, provided the data. Jermani grew up speaking Apurímac Quechua with his family and had infrequent exposure to Spanish before entering the Peruvian school system. Jermani also speaks English with high proficiency. Jermani read through the experiment at his own pace in a single session. Recordings were made using Praat (Boersma and Weenink 2019) in a soundproof booth with a head mounted microphone and a Mac-Book laptop computer.

3.2 Measurements

Apurímac Quechua ejective and pulmonic stops were compared with respect to three acoustic measurements previously found to distinguish ejective from pulmonic stops in languages like Délı\textma\'ųne Slavey, Hul’q’umi’num’, Tsilhqot’in, and Witsuwit’en (Percival 2015, 2019, Ham 2007, Hargus 2007). One property was of stops themselves (VOT), and two acoustic measures were made on the vowel directly after each stop (amplitude rise and F0 change). VOT is the time period between the release of a stop and the onset of voicing of its following vowel (Lisker and Abramson 1964). The stop release and start of vowel voicing were first manually marked in Praat (Boersma and Weenink 2019) (Figure 1). VOTs were then automatically calculated as the duration between the start of
voicing and the stop release using Lennes (2003)’s script.

Amplitude rise\(^6\) (measured in dB) (Figure 2) determines whether a vowel after a stop abruptly or gradually reaches its maximum amplitude. Large amplitude rise values indicate that a vowel is gradual to rise to its maximum amplitude, and small amplitude rise values are associated with a fast rise to maximum amplitude (Hargus 2007). One way to measure amplitude rise is to take the “difference between energy at vowel peak and 30 m/s after vowel onset” (Hargus 2007:80). This method does not account for vowels’ different durations. Amplitude rise was instead measured as the difference between a vowel’s maximum amplitude and its amplitude at the time-normalized onset, as seen in Figure 2. The onset of each target /a/ vowel was manually marked in Praat (Boersma and Weenink 2019). The Prosody Pro script then extracted the maximum amplitude for each vowel and separated each vowel into 10 time-normalized intervals, each with a mean amplitude (Xu 2013). The vowel onset amplitude was the mean amplitude over the first time-normalized interval.

\(^6\)This measure is often called rise time (e.g. Hargus 2007) or amplitude perturbation (e.g. Ham 2007). This term is renamed to amplitude rise to avoid confusion with phonetic shimmer, a different measure of amplitude perturbation. A reviewer also noted that rise time may be confusing, because this measure is of amplitude (dB), not time (ms).
Shown in Figure 3, F0 change\(^7\) (measured in Hz) measures the F0 trajectory of a vowel following a stop toward its midpoint. Negative F0 change values indicate that a vowel has a higher F0 at its midpoint than at its onset (rising contour), and a positive F0 value indicates that the vowel onset F0 is higher than its midpoint F0 (falling contour). Prosody Pro extracted the mean F0 values across 10 time normalized intervals using (Xu 2013). The mean F0 of the first time normalized interval was the vowel onset F0, and the mean F0 of the fifth time-normalized interval was the vowel midpoint F0. F0 change was calculated the difference between the F0 at the onset and the midpoint.

\(^7\)Often called F0 perturbation (e.g. Ham 2007), but renamed to F0 change here instead to avoid confusion with phonetic jitter, a different parameter of F0 perturbation.
3.3 Results

Figure 4 shows mean VOTs. The mean VOT of 60 total ejective stops (43 ms) was greater than the mean VOT of all 90 pulmonic stops (17 ms) across all places of articulation. This difference is significant, using a 2 sample t-test assuming unequal variances at a p level of .05. The difference between the average VOT of ejective and pulmonic stops is 25 ms.

![Figure 3: F0 change of /a/.](image)

![Figure 4: Mean VOTs.](image)

Figure 5 shows mean amplitude rise values across each place of articulation. The average amplitude rise of vowels following ejective stops (7.74 dB) was greater than that of vowels following pulmonic stops (4.85 dB). This difference indicates that vowels following ejective stops are slower to rise to their maximum amplitude than vowels following pulmonic stops. This
difference in average amplitude rise is significantly different for vowels following ejective stops than for vowels following pulmonic stops at a p level of .05, using a 2-sample t-test assuming unequal variances. Although statistically significant, this difference in average rise between pulmonic and ejective stops is small (2.89 dB), which suggests that amplitude rise is a less-robust acoustic cue for distinguishing ejective from pulmonic stops than VOT.

![Figure 5: Mean amplitude rise of postvocalic stops.](image)

Average F0 change values did not significantly differ between vowels following ejective and pulmonic stops, nor are there any trends by place of articulation. Average F0 change values are negligible when compared to the overall average F0 values for the speaker's vowels (around 141-142 Hz), see Figure 6. The average F0 change value for vowels following ejective stops (across all places of articulation) was -.16 Hz, and the average F0 change value for vowels following pulmonic stops was -.02 Hz. Using a 2-sample t-test assuming unequal variances, the difference in average F0 change values between ejective and pulmonic stops is not statistically significant at a p level of .05.

![Figure 6: Mean F0 change of postvocalic stops.](image)

4 Classifying Ejectives

4.1 Evaluating the Strong-Weak System

Apurímac Quechua ejectives have acoustic properties of both strong and weak ejectives, when defined according to Lindau (1984), Kingston (1985), and Wright et al. (2002)’s notion of strong and weak. Comparatively long VOTs suggest that Apurímac Quechua ejectives pattern like strong ejectives. Yet, the finding that vowels after ejectives gradually rise to their maximum amplitude indicates that Apurímac Quechua ejectives are weak. Average F0 change values did not significantly differ between vowels following ejective versus pulmonic stops, so F0 change is not considered a defining feature of Apurímac Quechua ejectives. The dichotomous classification system proposed in Lindau (1984), Kingston (1985), and Wright et al (2002) does not suitably describe Apurímac Quechua ejectives.

Apurímac Quechua is not alone in the challenges of classifying its ejectives. Other languages,
too, have ejectives that not neatly fit the strong-weak typology when classified using the three properties examined here (VOT, amplitude rise, F0 change). Table 5 displays languages with mixed ejectives according to the three properties. Warner (1996) determined that ejective stops in the Caucasoid language Ingush have a relatively long VOT and are followed by vowels with a relatively high F0 when compared to pulmonic stops. These F0 and VOT properties indicate that Ingush ejectives are strong. On the other hand, vowels after Ingush ejectives rose more slowly to maximum amplitude than pulmonic stops, suggesting a weak ejective. Tsilhqut’în and Witsuwit’en (both Athabaskan) likewise exhibit characteristics of both strong and weak ejectives (Ham 2004, Hargus 2006). Tsilhqut’în and Witsuwit’en ejective have longer mean VOTs than pulmonic stops, with long VOTs characteristic of a strong ejective. Vowels after ejectives in Tsilhqut’în and Witsuwit’en pattern after weak ejectives, with vowels beginning with a low F0 and rising slowly to their maximum amplitude. The labels strong (or stiff) or weak (or slack) do not adequately describe ejectives in Apurímac Quechua, Ingush, Tsilhqut’în, and Witsuwit’en.

<table>
<thead>
<tr>
<th>Apurímac Quechua</th>
<th>VOT</th>
<th>Amplitude rise</th>
<th>F0 change</th>
<th>Overall classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingush</td>
<td>strong</td>
<td>weak</td>
<td>not significant</td>
<td>mixed</td>
</tr>
<tr>
<td>Tsilhqut’în</td>
<td>strong</td>
<td>weak</td>
<td>weak</td>
<td>mixed</td>
</tr>
<tr>
<td>Witsuwit’en</td>
<td>strong</td>
<td>weak</td>
<td>weak</td>
<td>mixed</td>
</tr>
</tbody>
</table>

Table 5: Classification of mixed ejectives.

4.2 Alternative Approaches to Categorizing Ejectives

Given these findings that ejectives within a language may be contradictorily strong and weak based on their acoustic properties, the dichotomous strong-weak classification system does not sufficiently describe ejectives. Nelson (2010) proposes an alternative in which ejectives are simply described according to their individual acoustic properties (e.g., long amplitude rise, long VOT, creaky phonation). Although this level of detail does capture the large degree of variation present in ejectives’ acoustic properties, a large number of available acoustic properties makes cross-language comparison difficult. Wright et al. (2002) propose another possible alternative to the strong-weak system, in which ejectives are described using three dimensions: lengthwise vocal fold tension, medial vocal fold compression and larynx raising. The downside of this system is that these three dimensions are difficult to measure directly.

I propose a revision to the strong-weak system in which ejectives are labelled strong or weak according to two groups of acoustic properties: inherent properties and coarticulatory properties. Inherent properties are any measures of the ejective consonant itself, e.g., VOT or total duration. Coarticulatory measures encompass phonetic properties of the segment directly following an ejective, including measures like amplitude rise, F0 change, or phonation of the following vowel. According to this revised system, Apurímac Quechua ejectives are strong according to their inherent properties (reflecting the finding that Apurímac Quechua ejectives tend to have longer VOTs than pulmonic stops) but have weak coarticulatory properties (Apurímac Quechua ejectives tend to rise slowly to their maximum amplitude). The benefit of this revised system is that it simplifies a large number of possible acoustic measures (e.g., those in Table 2) as either inherent measures or coarticulatory measures. However, the need to handle ejectives’ interlanguage variability (e.g., conditioned by word position, morphological, or prosodic factors) remains in this new approach.

The presence of a reliable system of describing ejectives remains important for cross-language comparison and identification of emergent patterns. For instance, the Athabaskan languages mentioned here (Tsilhqut’în, Witsuwit’en, Délîne Slavey, Hän from Ham 2004, Hargus 2006, Percival 2015, Manker 2012, respectively) appear to pattern similarly with respect to long VOTs and long overall durations.

5 Conclusion

This paper has analyzed acoustic characteristics of Apurímac Quechua ejective stops with reference to the strong-weak system that categorizes ejectives based on their acoustic properties (Lindau 1984,
Kingston 1985, Wright et al. 2002). The suitability of this classification system based on the acoustic characteristics of Apurimac Quechua ejectives, in conjunction with data on ejectives from a sample of other languages, was assessed.

Apurimac Quechua ejectives are neither fully strong nor fully weak, based on the acoustic properties assessed in the current study. It was concluded that the (Lindau 1984, Kingston 1985, Wright et al. 2002)’s strong-weak dichotomy is insufficient to describe Apurimac Quechua ejectives, additional problems with this current system were presented, and possible alternatives were discussed.

References


Vogel, Irene. Prosodic Typologies Lab. URL https://sites.google.com/site/udstresslab/home

Department of Linguistics and Cognitive Science
University of Delaware
Newark, DE, 19716
marcinko@udel.edu