TSILHQUT'IN EJECTIVES*

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This paper reports findings from an instrumental study of ejectives in Tsilhqut'in, a Northern Athabaskan language. The study was of an attempt to seek an answer to the following research questions: Do Tsilhqut'in ejectives pattern as *strong* or *weak*, agreeing with a traditional binary classification (e.g., Lindau 1984 and Kingston 1985)? Or, something in between?

Overall results point to phonetic variability of ejectives observed with such languages as Ingush (Warner 1996), Witsuwit'en (Wright, Hargus, and Davis 2002), and Carrier (Bird 2002) and to support the need for the dichotomous typology of ejectives to be reconsidered.

1. Theoretical Context

1.1 Ejective Typology and Research Questions

Previous studies of ejectives, such as Lindau 1984 and Kingston 1985, have shown that ejectives tend to fall into two categories: strong vs. weak, or stiff vs. slack. "Strong" ejectives usually have long voice onset time (VOT), modal or tense voice, raised pitch and a sudden amplitude increase at the onset of voicing, and are easy to perceive. On the other hand, "weak" ejectives are likely to have short VOT, creaky voice, lowered pitch and a gradual amplitude increase at the onset of voicing, and are hard to perceive. Table 1 below summarizes these acoustic correlates found from past work (e.g., Lindau 1984, Kingston 1985, Bird 2002, Wright et al. 2002, and Hargus 2007).

Table 1. Ejectives: Strong (e.g., Navajo) vs. Weak (e.g., Hausa)

Correlates	Strong ejectives	Weak ejectives
VOT	long	short
Voice Quality	modal or tense	creaky
Pitch at Voicing Onset	raised	lowered
Amplitude at Voicing Onset	sudden increase	gradual increase
Ease of Perception	easy	hard

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While it has traditionally been assumed that languages choose one or the other type of ejectives, more recent work, however, repeatedly reported considerable variability of ejectives at the phonetic level.

Warner (1996) instrumentally investigated ejectives in Ingush, a Northeast Caucasian language, and found that Ingush ejectives did not pattern as strong or weak. They had acoustic properties that were a combination of both types. For instance, pitch was higher at the voicing onset of a post-ejective vowel, whereas a rise of amplitude of a following vowel was slow (p.1528). Moreover, VOT, which is very short for weak ejectives (e.g., Hausa velar ejectives: 25 ms, see Table 10) and long for strong ejectives (e.g., Navajo velar ejectives: 80 ms, see Table 10), was found to be in between for Ingush velar ejectives (50 ms) (p.1528).

Wright, Hargus, and Davis (2002) acoustically studied alveolar ejectives in Witsuwit'en, a Northern Athabaskan language, and reported considerable inter-speaker variation. Although mean slow rise time, lowered f0, and creaky voice quality seem to suggest the sounds to be "slack," or weak, ejectives (p.65), out of eleven participants, there was no one speaker exactly fitting into this group categorization. Wright et al. therefore brought to our attention that the notion for *average* ejective is "problematic" (p.69) and that the dichotomous typology is "inadequate" (p.70) to account for the wide range of phonetic variation revealed in the production of Witsuwit'en ejectives.

While studying Lheidli, a dialect of Dakelh (Carrier), a Northern Athabaskan language, Bird (2002) also made a note on noticeable intra-speaker variation. In production of ejective stops, a single speaker of Lheidli varied between the two types of ejectives. Bird's auditory impressions with quantified differences in VOT seemed to be accordance with speaker variation that I also observed with ejectives in Tsilhqut'in, an Athabaskan neighbor of Dakelh, through a linguistic course offered at University of Victoria, in spring 2006.

1.2. Acoustic Correlates

Accordingly, in order to acoustically analyze and determine whether the Tsilhqut'in ejectives belong to either type of strong or weak ejectives or they pattern differently from this binary classification, four of the correlates, established from the previous work, were selected to be the measures of the present investigation: VOT, Jitter Perturbation, F0 Perturbation, and Rise Time.

To give a brief overview, the first measure *VOT* is to determine so-called voice onset time, a period between a burst of an ejective and onset of the voicing of a vowel following the ejective; the second *Jitter Perturbation*, to determine voice quality of the following vowel; and the third *F0 Perturbation* and the fourth *Rise Time*, to determine pitch and amplitude of the post-ejective vowel, respectively. VOT is an acoustic cue commonly used in comparing not just ejectives but also other types of stops among many languages (e.g., English stops vs. French stops). The voice quality, pitch, and amplitude of a vowel after an ejective compose a large part of the whole phonetic nature of ejectives (e.g., Lindau 1984, Kingston 1985, Warner 1996, and McDonough 2003). These four measures were chosen for the current study because they have been used in other studies of ejectives, such as McDonough and Ladefoged (1993), Warner (1996), Wright et al. (2002), and Hargus (2007), and found to show acoustic features distinguishing ejectives from other types of stops.

Before we get into details of the current study, let me first give you a general description of the Tsilhqut’in language as background.

1.3 General Language Background

Tsilhqut’in, pronounced as [tsɪɬqot’ˀin] and also written as Chilcotin, is an Athabaskan language spoken in the region between the Tsilhqut’in (Chilcotin) watershed and the Coast Range in the interior of British Columbia, Canada. Most of its communities are situated in the vicinity of Williams Lake, along the Chilco and Chilcotin Rivers. Tsilhqut’in belongs to the Northern Athabaskan language family, and Carrier is its only Athabaskan neighbor (Lane 1981 and Mithun 1999).

As typical of many Athabaskan languages, Tsilhqut’in has a rich and complex consonant inventory. As shown in Table 2 below, it consists of 3 laryngeal types of stops, voiced and voiceless fricatives, nasals, and glides across places of articulation, from labial to coronal, dorsal, and/or glottal.

Table 2. Tsilhqut’in Consonant Inventory[1]

		Labial	Dental	Lateral	Alveolar	Pharyngealized Alveolar	Alveo-Palatal	Velar	Labio-Velar	Uvular	Labio-Uvular	Glottal
Obstruents	Plain	b	d	dl	dz	d̠z̠	dʒ	g	g^w	G	G^w	ʔ
	Aspirated	p	t	tɬ	ts	t̠s̠	tʃ	k	k^w	q	q^w	
	Ejective		t’	tɬ’	ts’	t̠s̠’	tʃ’	k’	k^w’	q’	q^w’	
Fricatives	Voiceless			ɬ	s	s̠	ʃ		x^w	χ	$χ^w$	h
	Voiced			l	z	z̠				ʁ		
Sonorants		m	n				j		w		w̠	

According to the literature (e.g., Helm 1981, Krauss and Golla 1981, and Holton 2000), there is a noticed orthographic tradition across Athabaskan languages. Unaspirated (or plain) stops and affricates are written with the corresponding voiced stop and affricate symbols, whereas voiceless aspirates are written with the corresponding voiceless stop and affricate symbols. Therefore,

[1] Adapted from Tuttle 1998, Holton 2000, Gessner 2003, and Russell and Myers 2005.

the dental series *d, t, t'* in orthography and in Table 2, for example, corresponds to [t, tʰ, t'] in IPA. It should also be noted that based on Krauss and Golla (1981), there is ambiguity whether the fricatives *x* and *gh* are velar ([x, ɣ]) or uvular ([χ, ʁ]) in Tsilhqut'in. Since this issue is beyond the scope of the present study, it will not be dealt here.

As seen in Table 2, Tsilhqut'in stops form a three-way contrast according to their laryngeal specification: plain (or unaspirated), aspirated, and ejective (or glottalized). Among these stops, only those in a complete contrastive set were used for acoustic analyses and comparisons of the current study. In other words, labial and glottal stops *b*, *p*, and *ʔ* were excluded from the instrumental investigation since they were not in a full three-way distinction as the rest of the stops were.

2 The Phonetic Study

2.1 Data

The data used in this study comes from two resources of the Tsilhqut'in language. One is a corpus of some 500 entries of words, phrases, and sentences compiled through a Linguistics Field Methods course. Our class elicitations with language consultant Lois William, group/class discussions, and individual observations were recorded in a classroom setting using a Sony MZ-B10 Portable Mini-Disc Recorder and an external microphone. The recordings then were digitized and saved as WAV files using the Audacity digital audio editor (version 1.2.4).

The other resource is a copy of the Swadesh List[2] CD created at the Center for Comparative Psycholinguistics, University of Alberta in July 2004 [3]. A list of 142 common words, prepared by Maria Myers, was recorded with two speakers: Helena and Maria Myers in a sound booth, using two head mounted microphones. The Myers, mother and daughter, are Tsilhqut'in speakers, and Maria has experience in Tsilhqut'in language teaching. The recording was made in such a way that daughter Maria repeated each word on the wordlist three times, and then her mother pronounced the same word three times[4].

From these corpi, a total of 229 "stem-initial" (12 word-initial + 217 non-initial) stop tokens were selected and compiled in SPSS (Statistical Package for the Social Sciences, SPSS Inc., 1968). Table 3 below summarizes the whole dataset.

[2] A Swadesh list is a prescribed list of basic vocabulary. It was named after Morris Swadesh, an American linguist, who created the list in the 1940-50s.

[3] A version of the wordlist with the orthography and the meaning of each word was also provided for this study by another Tsilhqut'in language expert Linda Smith.

[4] When there was a question by Helena Myers of what the word was, Maria Myers provided to her some explanations (e.g., contextual information) for clarification. All these extra conversations between the Myers were saved intact in the recording.

Table 3. Token Counts: plain, aspirated, and ejective stops across 9 places of articulation.

		Dental	Lateral	Alveolar	Pharyngealized Alveolar	Alveo-Palatal	Velar	Labio-Velar	Uvular	Labio-Uvular
Obstruents	Plain	d	dl	dz	d̠z̠	dʒ	g	g^{w}	G	G^{w}
	106	49	10	11	0	15	17	4	0	0
	Aspirated	t	tɬ	ts	t̠s̠	tʃ	k	k^{w}	q	q^{w}
	80	30	0	17	2	7	2	4	16	2
	Ejective	t’	tɬ’	ts’	t̠s̠’	tʃ’	k’	k^{w}’	q’	q^{w}’
	43	9	3	9	0	7	6	4	5	0
Total	**229**	**88**	**13**	**37**	**2**	**29**	**25**	**12**	**21**	**2**

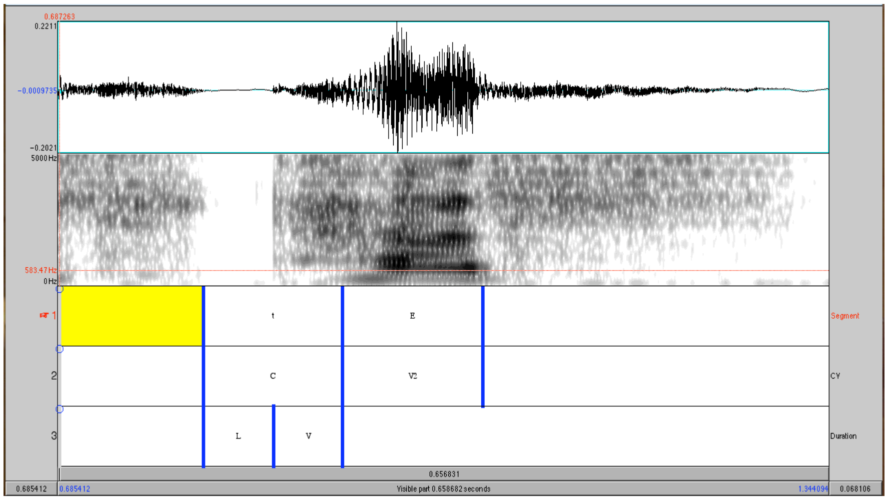
The morphological control of the tokens to be uniformly “stem-initial” in fact bears significance since past work has shown the importance of morphology in affecting the phonetic features of Athabaskan languages (Tuttle 1998, Holton 2002, Gessner 2003, McDonough 2003, Bird 2004, Rice and Hargus 2005, and Hargus 2007). Another note on the dataset is that 12 word-initial stops had to be excluded from the duration measures, except for VOT. It should also be noticed that there is an unevenness in token counts.

2.2 Segmenting

As you may recall the research questions – do Tsilhqut’in ejectives pattern in terms of strong vs. weak; or, something else? – Tsilhqut’in ejectives needed to be phonetically described. In order to seek an answer to the questions, 2 major comparisons were therefore conducted:

- Intra-language Comparison: compare Tsilhqut’in ejectives with their contrasting, plain and aspirated, stops within the language
- Inter-language Comparison: compare Tsilhqut’in ejectives with ejectives in other languages

To begin, each of 229 tokens was segmented by using tiers in Praat, the speech analysis software created by Paul Boersma and David Weenink (2006). That is, boundaries were placed around each of a preceding vowel, stop, and a following vowel (i.e., | (V1) | C | V2 |). Each stop (C) was further divided into 2 periods: closure and VOT (i.e., | L | V |). Example 1 below illustrates the segmentation.



Example 1. [tɛ] as in [jədɛniɬtɛɬ] ‘s/he shot it (with a gun)

To be systematic and consistent in segmenting, I followed the method used in Warner & Arai 2001 and Warner et al. 2004. For instance, the start of the vowel, following the voiceless stop, is the onset of voicing, as seen in the example above.

2.3 Four Measures

Using a Praat script, I then obtained from these marked segments - C, V2, L, and V - 4 measures: Duration, Jitter perturbation, F0 Perturbation, and Rise Time. I visually examined the waveform and spectrograph of each token and made sure if the script was taking the measurements correctly (i.e., by double-checking the values manually).

In the following sections, I will, with some visual illustrations, provide a general description of each of the measures and how the measurements were obtained.

2.3.1 VOT

A stop can be divided into 2 periods: closure and release. VOT, also called the “release period”, is “the period from the release of the burst [of the stop] to the onset of the voicing [of the following vowel]” (McDonough 2003). Thus, what was acoustically measured of each stop is the duration of such a period that is marked as ③ in Figure 1 and Figure 2 below.

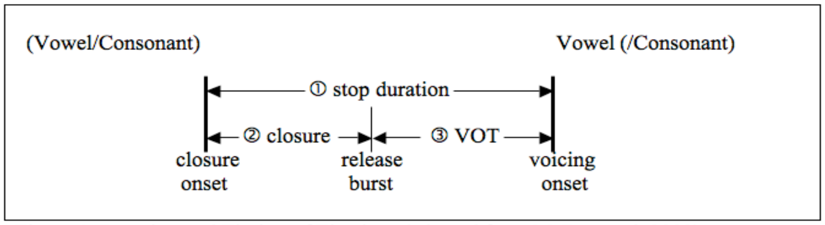


Figure 1. Duration and Timing of Ejectives (adapted from McDonough 2003)

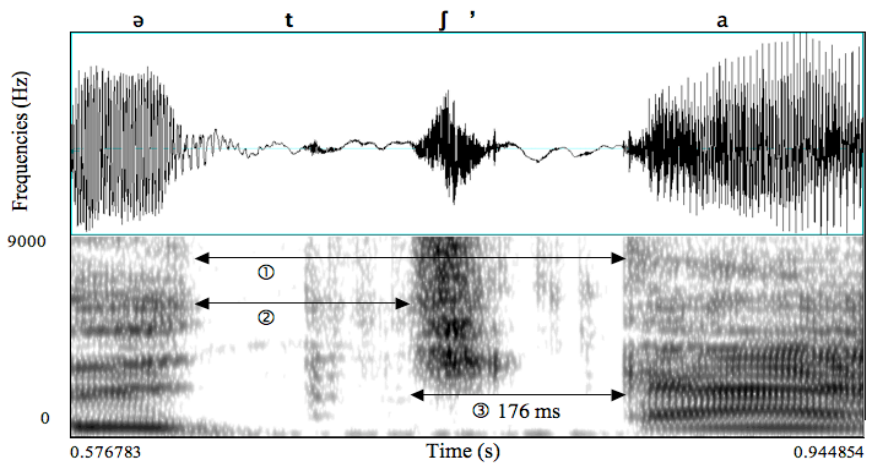


Figure 2. [ətʃ'a] as in [sətʃ'an] 'Before me (as in "before my time")'

The alveo-palatal ejective [tʃ'] in Figure 2 above had VOT 176 ms.

2.3.2 Jitter Perturbation

Jitter perturbation measures a degree of periodicity (i.e., regularity of the pitch pulses) of a vowel after a stop. This acoustic cue, often together with other correlates, such as spectral noise, is used to distinguish between phonation types. Creaky voice, for example, typically yields jitter values higher than those of modal or breathy voice. I took jitter measurements of every token from 30 ms windows[5] at two points in the following vowel: at the onset of the voicing and at the midpoint[6].

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[5] For a few tokens, marked with an asterisk in APPENDIX II, the window was enlarged from 30ms to 50 ms to get jitter values.

[6] Following the methodology used in the previous study of Witsuwit'en stops by Wright, Hargus, and Davis (2002), I am grateful to Dr. Sharon Hargus for sending me a copy of this invaluable study even before its publication.

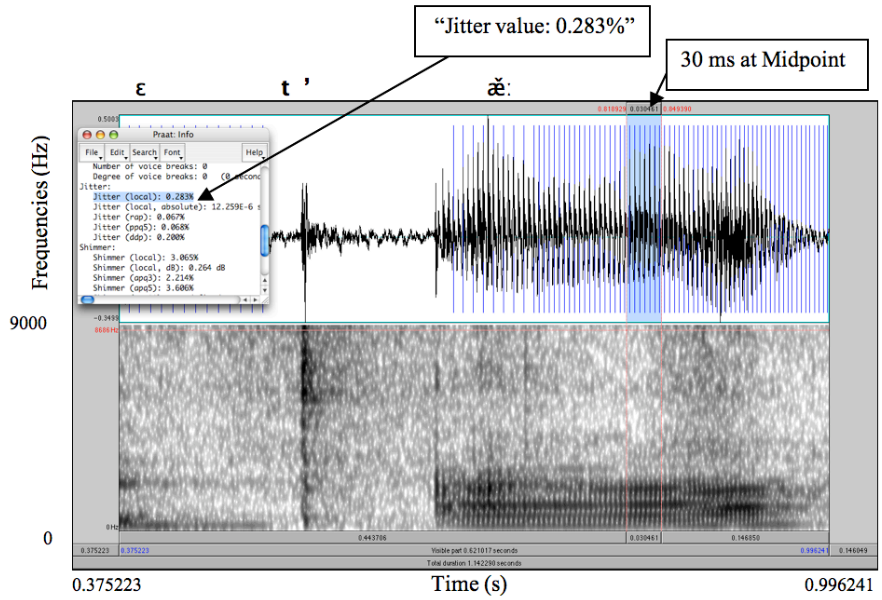

Figure 3. [ɛˈt'æ̆ː] as in [sɛˈt'æ̆ː] 'My wings'

Figure 3 above provides an example of a jitter value (0.283%) taken from a 30 ms window at a midpoint of a vowel [æ̆ː] following a dental ejective [**t'**].

2.3.3 F0 Perturbation

The next measure f0 perturbation is to see if there is any change or difference in pitch from voicing onset to a midpoint of a vowel and to determine how big the difference, if any, is. That is, fundamental frequencies (f0) of a vowel following each stop were obtained from 30 ms windows at two points – the onset of voicing and the midpoint of the vowel. Then, the discrepancy between the points was calculated. Figure 4 below is to illustrate how f0 (252 Hz) was obtained from 30 ms window at a midpoint of a vowel [ʌ] after a labio-velar ejective [**kʷ'**].

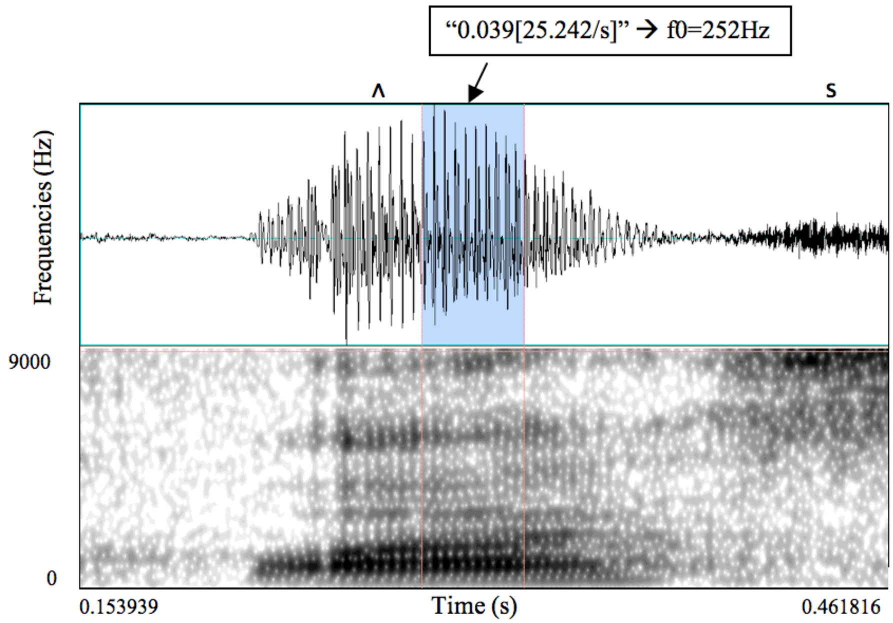

Figure 4. [ʌs] as in [kʷ'ʌs] 'Cloud'

2.3.4 Rise Time

For the last measure, Rise time, intensity values were taken at 3 points - at the voicing onset, 30 ms later, and the peak of a following vowel. Although these values showed an overall "energy" pattern, rise time is defined as "the difference between energy at vowel peak and energy at 30 ms after vowel onset" (Hargus 2007: draft p.100). Previous studies, like Wright et al. 2002 and Hargus 2007, found a main cue to ejectives to be the difference between the peak and 30 ms into a post-ejective vowel. In other words, such a difference in amplitude between the two points separates ejectives from the other stops. The example in Figure 5 below had 76.35 dB at the peak intensity.

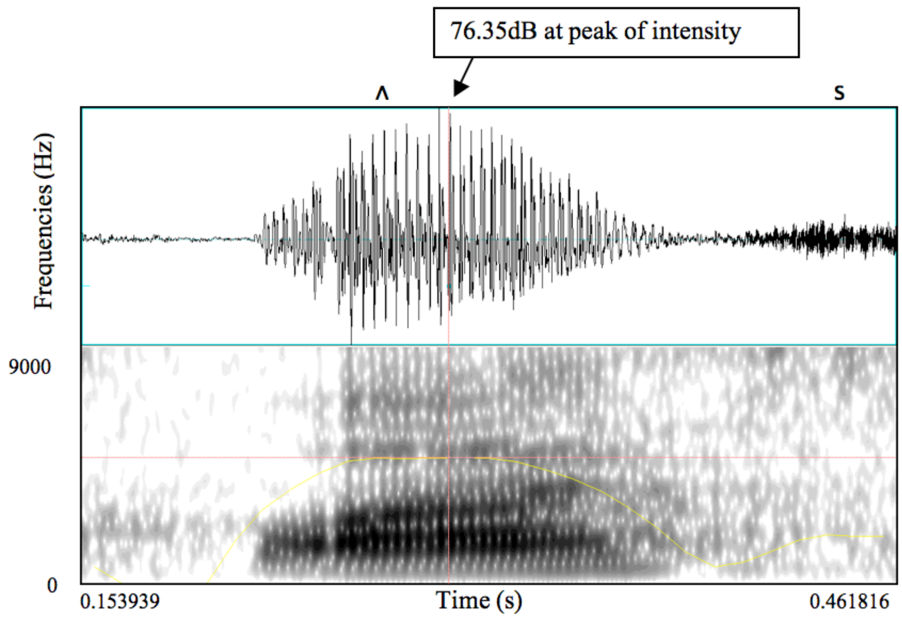

Figure 5. [ʌs] as in [kʷʼʌs] ‘Cloud’

Based on the model used in the two Witsuwit’en studies (Wright et al. 2002 and Hargus 2007), these measures were “normalized” (p.14). The formulas for the normalization are shown in Table 4 below.

Table 4. Normalization of Acoustic Measures[7]

Jitter Perturbation	mean jitter at onset of voicing – mean jitter at vowel midpoint
F0 Perturbation	mean f0 at onset of voicing – mean f0 at vowel midpoint
Rise time	mean energy over vowel peak – mean energy at 30 ms from vowel onset

According to the authors, in this way, we standardize “individual differences in pitch, voice quality, or speech intensity” and are able to make generalizations across speakers (p.14).

3 Results and Findings

3.1 Intra-language Comparison

Firstly, overall results from mean VOT’s with Closure duration (L) and Stop duration (C) are summarized in Table below.

[7] Adapted from Wright et al. 2002 (Table 7).

Table 6. Mean duration across 3 stop groups

	Closure-L (ms)	VOT-V (ms)	Stop-C (ms)
Plain	76 (45) [8]	**46 (45)**	122 (72)
Aspirated	78 (49)	**105 (47)**	183 (76)
Ejective	67 (48)	**102 (54)**	155 (77) [9]

In contrast to the much shorter VOT of the plain (mean 46 ms, SD 45 ms), the ejectives had the long VOT (mean 102 ms, SD 54 ms). The finding that the ejectives pattern similarly with the aspirated (mean 105 ms, SD 47 ms) in terms of VOT indicates that Tsilhqut'in ejectives are *strong*.

Secondly, mean jitter values obtained from the entire dataset are shown in Table 7 below.

Table 7. Mean jitter across 3 stop groups

	V2 onset (%)	V2 mid (%)	Jitter perturbation: V2 onset - mid (%)
Plain	2.0 (1.5)	0.6 (0.4)	1.4 (1.5)
Aspirated	2.3 (1.6)	1.1 (3.5)	1.2 (3.9)
Ejective	**3.8 (3.0)**	**1.2 (1.5)**	**2.5 (3.4)**

As seen, among the three stops, the ejectives showed the highest initial jitter (mean 3.8%, SD 3.0%) and the biggest decrease towards the vowel midpoint (mean 2.5%, SD 3.4%). This finding points to the sounds being *weak* ejectives.

Thirdly, Table 8 below shows results from mean f0 perturbation measurements.

Table 8. Mean f0 across 3 stop groups

	V2 onset (Hz)	V2 mid (Hz)	F0 perturbation: V2 onset - mid (Hz)
Plain	218 (31)	211 (30)	8 (23)
Aspirated	224 (34)	215 (32)	8 (16)
Ejective	**209 (45)**	**214 (33)**	**-5 (38)**

[8] Figures in parentheses indicate standard deviation (SD).

[9] Notice that in case of the ejectives, the sum of the Closure duration (L) and the VOT (V) does not equal to the Stop duration (C) (i.e., $67 + 102 \neq 155$). It is because 12 out of 43 ejective tokens were word-initial and thus could be only measured for VOT, not for the other two durations. In other words, 67 ms and 155 ms are mean L and mean C of 31 ejectives, respectively, while 102 ms is mean V of 43 ejective tokens (see section **2.1**).

Compared to the other stops, the ejectives had the lowest pitch at the voicing onset (mean 209Hz, SD 45Hz) and then the biggest increase into the midpoint of the vowel (mean -5Hz, SD 38Hz). This is another indication that the ejectives are *weak*. It is interesting to see the results of jitter and f0 perturbation values agree here as creaky voice and pitch sometimes go together (i.e., creaky voice has low f0).

Finally, the results from the last measure are summarized in Table 9 below.

Table 9. Mean rise time across 3 stop groups

	V2 onset (dB)	V2 30 ms (dB)	V2 peak (dB)	Rise time: V2 peak - 30 ms (dB)
Plain	71.6 (8.8)	75.8 (8.4)	77.2 (8.0)	1.4 (1.5)
Aspirated	66.8 (8.4)	72.8 (7.7)	74.2 (7.3)	1.4 (1.2)
Ejective	57.8 (9.6)	**65.3 (7.6)**	**69.8 (6.3)**	**4.5 (3.3)**

As illustrated above, the mean rise time results revealed that the ejectives had the slowest rise time (mean 4.5dB, SD 3.3dB), contrasting the much quicker rise time, 1.4dB, of the plain and aspirated stops (SD 1.5dB and SD 1.2dB, respectively). The results support that the ejectives are *weak*.

In order to demonstrate this contrast clearly, I prepared Chart 1 spotting the intensity values at the 3 points – the voicing onset, 30 ms, and the peak.

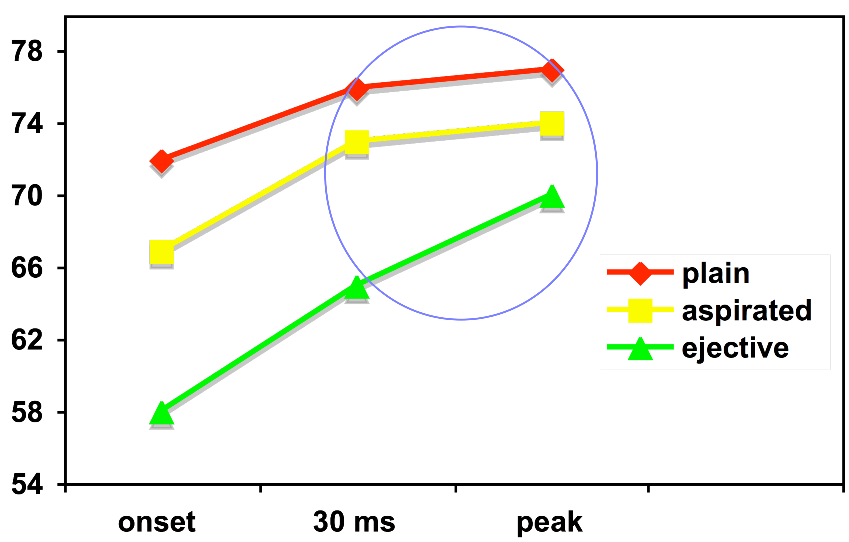

Chart 1. Line chart with mean rise time values at 3 points

As shown by the overall slop patterns in the chart, the mean intensity of the plain and aspirated stops increased most from voicing onset to 30 ms into the vowel. By then, the intensity level was already near its peak and, thus, did not have much more to rise from there. On the other hand, the mean intensity of the ejectives continued to increase, or "rise," from the voicing onset through 30 ms later and until its peak, thus showing the rise time slowest among the three stop groups. These results coincide with what Wright et al. 2002 and Hargus 2007 found of Witsuwit'en ejectives. Witsuwit'en ejectives also had a slower rise time, or a greater difference, between the 30 ms point and the peak energy of the vowel than either the plain or aspirated stops. This period, marked with a circle in the chart, thus distinguished the ejectives from the other stops.

To sum up, compared to the plain and aspirated stops, the Tsilhqut'in ejectives had longer VOT (burst - voicing onset duration), higher jitter (creaky quality) at voicing onset, lower f0 (pitch) at voicing onset, and slower rise time (intensity) between 30 ms after voicing onset and peak. While the long VOT indicates that the ejectives may be *strong*, the higher initial jitter, lower initial pitch, and the slower rise time point them to being *weak*.

3.2 Inter-language Comparison

With all we have so far learned of Tsilhqut'in ejectives in terms of the four acoustic characteristics, we can now make the second comparison between ejectives in Tsilhqut'in and other languages. This inter-language comparison among seven different languages - Ingush, Hausa, Quiché, Tigrinya, Navajo, Witsuwit'en, and Tsilhqut'in – is summarized in Table 10 below.

Table 10. Comparison of Acoustic Characteristics of Ejectives across Languages (Adapted from Warner 1996)

	Ingush	Hausa	Quiché	Tigrinya	Navajo	Witsuwit'en - alveolars	Tsilhqut'in
VOT – velars (VOT)	50 ms	25 ms	50 ms	~ 80 ms	80 ms	33 ms	Velars – 73 ms Alveolars – 109 ms
Voice quality at voicing onset (Jitter)	aperio -dic	aperio -dic	creaky	modal	modal	creaky (6.9%)	(creaky?) (2.5%)
Pitch at voicing onset (F0)	higher	-	lower	higher	-	lower (-9Hz)	lower (-5Hz)
Rise to full amplitude (Rise Time)	slow	normal	slow	fast	very fast	slow (5dB)	slow (4.5dB)
Traditional Classification	**?**	**weak**	**weak?**	**strong**	**strong**	**weak**	**?**

As you can see in the last row of the table above, “Traditional Classification,” if we were to classify these ejectives into either *strong* or *weak*, we would run into a problem with the languages like Tsilhqut’in, Ingush, and Quiché since they do not exactly pattern as either of the types. That is, these languages have a combination of *both* strong and weak properties at the phonetic level. As discussed in the previous section, Tsilhqut’in ejectives showed long VOT that is of the *strong* qualities. They also had creaky voice, lower pitch at the voicing onset, and slower rise time to full intensity, which are of the *weak* traits. In the case of Ingush ejectives, their higher pitch at the onset of the voicing is an indication of the *strong*, whereas their slow rise time is of the *weak*. Their VOT (50 ms) and aperiodic voice quality of the voicing onset cause even more difficulty classifying the ejectives into either of the types since they fall somewhere between the two. Likewise, the VOT (50 ms) of Quiché ejectives is neither as long as that of Novajo ejectives (80 ms) nor as short as that of Hausa ejectives (25 ms). Moreover, although the acoustic characteristics of Witsuwit’en alveolars seem to match with those of weak ejectives, we must not forget the wide range of the inter-speaker variation that Wright et al. (2002) and Hargus (2007) pointed out through their instrumental studies (see section **1.1**).

4. Overall Conclusions and Future Directions

Going back to the research questions, an overall conclusion we can draw from all the findings discussed so far is that Tsilhqut’in ejectives are *not* either strong or weak, but something *between*. These findings support what more recent studies (e.g., Warner 1996 and Bird 2002) have found of ejectives in some Athabaskan and non-Athabaskan languages – considerable *variability* at the phonetic level.

The overall results of the present study therefore indicate that the binary classification is neither universal nor categorical and suggest need for the traditional dichotomous typology of ejectives to be reconsidered.

For future research, there are a number of things to be looked into as the current study bears many limitations. For one, more tokens need to be collected. This can allow each type of ejectives to be more even in counts and ultimately can yield results that are more representative of the Tsilhqut’in language. For another, further expanded and enhanced investigations by both acoustic and articulatory analyses are desirable to determine a more complete picture of the phonetic nature of the Tsilhqut’in ejectives. For instance, those word-initial stops that had to be excluded from some duration measurements (e.g., closure period (L)) in this study, since it was impossible to acoustically measure (i.e., by using Praat), can be articulatorily detected. In other words, where the articulation of the onset stops begins can be measured by using Ultra Sound machine, for example. Lastly, in general, more research of ejectives in different languages is needed. More information about ejectives in a variety of language, such as actual values (e.g., VOT 67 ms), will be extremely helpful to make a precise comparison among the ejectives and eventually to find a better way of categorizing these intriguing sounds in the world languages.

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