

Tsilhqut'in Ejectives: A Descriptive Phonetic Study

by

SooYoun Ham  
B.A., University of Victoria, 2004

A Thesis Submitted in Partial Fulfillment of the  
Requirements for the Degree of

MASTER OF ARTS

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**ABSTRACT**

Stops are one of the most common sounds across languages of the world. Among these pervasive sounds, ejectives form a unique group that is distinguishable from other types of stops. Their particular mechanism of articulation, such as larynx raising and unusually high oral pressure, separates them from the others. More interestingly, a listener perceives them differently and makes a distinction from non-ejective, or pulmonic, stops. What is it that we perceive when hearing ejectives? Do we perceive certain acoustic cues or auditory qualities that are part of their distinctive phonetic nature? Are these phonetic characteristics always distinctive? In other words, is our perception of the ejectives always consistent without any variation at the phonetic level?

Motivated by these questions and from my recent exposure to Tsilhqut'in ejectives, I set out to pursue a phonetic investigation of these intriguing sounds. The present study is composed of two main analyses. One is an acoustic analysis that

instrumentally examines a dataset of ejective and non-ejective stops in the Tsilhqut'in language with respect to acoustic dimensions such as Voice Onset Time (VOT) in order to compare all the stop classes in terms of their acoustic properties. Such a comparison helps to phonetically characterize the ejectives within the language. The acoustic measures also enable us to compare the characteristics of Tsilhqut'in ejectives with those in other languages, based on previously reported acoustic correlates. In order to determine the characteristics of ejectives across languages, Tsilhqut'in ejectives were compared with ejectives in different languages (e.g., Inguish). The other analysis is auditory, whereby I have examined how I perceived a subset of the ejectives taken out of the whole dataset and compared my auditory judgments with the acoustic measurements in order to find any correlation between results from the two analyses.

The findings of the study indicate that Tsilhqut'in ejectives do not follow a traditional binary typology of ejectives. That is, they are *neither* strong *nor* weak, as is often claimed in the literature. They are congruent with what recent studies (e.g., Warner 1996) have found of ejectives in other languages – *phonetic variability*. This means that the dichotomy cannot account for the variability in ejectives at the phonetic level and that an optimal way of classifying ejectives across languages still awaits discovery.

To the best of my knowledge, no other phonetic study has been conducted on Tsilhqut'in ejectives prior to the current study. Moreover, there has been little research or documentation carried out on any other phonetic aspects or sounds of this Athabaskan language. I expect that this instrumental study will contribute to the field of linguistics by adding new phonetic knowledge about such a rarely studied language, and I also expect

the present study to play a role in the understanding of language learning and of language revitalization around the world.

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## Chapter One

### INTRODUCTION

In this chapter, I will first talk about ejectives – a type of stops known to be one of the very pervasive sounds in world languages. I will then provide a general description of ejective articulation that I have learned from previous work (Section 1.1). In Section 1.2, my initial motivation to pursue a formal phonetic study of Tsilhqut'in ejectives will be described. In the last two sections, I will describe contributions that I hope the present investigation makes to the linguistic field (Section 1.3) and a summary of the rest of the chapters as an outline of the thesis (Section 1.4).

#### 1.1 Ejectives and Ejective Articulation

According to the literature (e.g. Ladefoged and Maddieson 1996, MacEachern 1996, Maddieson 1998b, Warner 1996, and Beck 2006), ejectives comprise a distinctive group of stops that are distinguishable in their articulation from other plain, or pulmonic, stops.

Ladefoged and Maddieson (1996), for instance, describe the articulation of ejectives as the production of a closed glottis, an occluded oral cavity, a raised larynx, and a compressed vocal tract above the glottis (p. 78). The great supraglottal pressure, almost double the pulmonic pressure, i.e. “from about 8 to about 16 cm H<sub>2</sub>O,” then causes a strong and intense burst of the ejective, much greater than that of a pulmonic stop (p. 78).

Maddieson (1998b) also talks about the same “ejective mechanism” – the larynx raised and the glottis closed simultaneously – involved in producing “weird sounds” like Tlingit ejective fricatives (p. 109). In addition, he shows that a sharp peak in intra-oral pressure near the beginning of the articulation of an ejective stop is significantly higher than that of non-ejective stops. This peak in intra-oral pressure is therefore one of their major aerodynamic characteristics (e.g. MacEachern 1996, Maddieson 1998b, and Beck 2006.).

Warner’s (1996) description is a good summary of the mechanism of ejective articulation:

Ejectives, which occur in approximately 16% of the world’s languages, are very different from the more common pulmonic stops in their articulation: the speaker makes an oral closure while simultaneously closing the glottis, then raises the larynx. This action causes an unusually high oral air pressure. The oral closure is then released, and the air rushes out of the mouth. At some point after the release of the oral closure, the glottal closure is also released (p. 1525).

She also raises a question about acoustic cues for ejectives: “what is it that listeners hear in [ejectives]?” (p. 1525). Such articulatorily unique aspects of ejectives as raised larynx and considerably high oral pressure cannot be seen or heard to listeners; yet, they perceive ejectives as auditorily distinctive from other types of stops (p. 1525). According to Esling (2005), this is because the larynx is constricted to make and sustain glottal stop closure. The reduction results in the predictable quality of laryngeal constriction, which has been called “raised-larynx voice,” or “pharyngealized voice” depending on pitch (Laver 1994). This quality can be perceived in the transition to the vowel. If there is no neighbouring vowel, then the shortened vocal tract will still reflect the tightened pressure to hold the stop and demonstrate higher-pitched noise ranges and possibly amplitudes.

## 1.2 Motivation

As shown through the previous studies of ejectives, it is only natural and expectable that one would hear the consonants quite differently from any other types of stops in speech, due to their unique articulation. Would this be true in every case, however? In my experience, their auditory distinctiveness does not seem to be consistent. I suspect that there should be some variability of ejectives at the phonetic level. For instance, during my first exposure to ejectives of Tsilhqut'in<sup>1</sup>, an Athabaskan<sup>2</sup> language<sup>3</sup>, I heard the same sounds sometimes as clear ejectives (e.g. /t'/), and other times, rather like other more common, pulmonic, stops (e.g. /t/)<sup>4</sup>. As I have perceptually noticed, there seemed to be sub-categories of the ejectives, appearing on the surface. These phonetic variations would be what the listeners detect in their auditory perception. It was in this manner that I initially became interested in such intriguing sounds in the Tsilhqut'in language. In other words, I was highly motivated and determined to pursue a phonetic study as my thesis research in order to investigate and find out about Tsilhqut'in ejectives and their phonetic variability.

Therefore, in the following chapter, I will provide a description of what I have found about ejectives from early studies in the literature. We will discuss accordingly categorizations and acoustic correlates of the ejective stops, established through past work on ejectives across languages.

---

<sup>1</sup> As will be seen later in the thesis, there are variations to spell the name of the language (e.g. Tsilhqot'n and Chilcotin).

<sup>2</sup> This word, also, is spelled in different ways, such as Athabaskan and Athapaskan.

<sup>3</sup> More information about the language is given in Chapter 2.

<sup>4</sup> This was the time when I heard some of the ejectives as identical to laryngealized, or fortis, stops in my native language, Korean.

### **1.3 Contribution of the Current Phonetic Study**

The current study of Tsilhqut'in ejectives aims to investigate instrumentally these intriguing sounds and verify their subjectively observed variability. In doing so, I expect that the present study will contribute to the linguistic field by adding new findings from an acoustic and auditory examination of such a rarely studied Indigenous language. To the best of my knowledge, no phonetic study of Tsilhqut'in ejectives exists prior to the current one. I also doubt that there is any phonetic investigation previously conducted on other sounds or aspects of the Tsilhqut'in language.

Another contribution that I expected to make through this study is phonetics-specific. That is, I hoped to determine the phonetic nature of the ejectives by quantitatively measuring and justifying their duration, pitch, voice quality, and amplitude. To compare the quantitative results with those of ejectives in other languages, I have tried to find earlier studies on ejectives. However, it has not been an easy task to search and obtain such important quantitative information about ejectives in other languages for the current study. Therefore, I am convinced that whatever would be found of Tsilhqut'in ejectives is certainly a useful reference and comparison in future research on ejectives and on ejective typology.

All the contributions that I expect the current study to make would not have been even thinkable without previous work on the Tsilhqut'in language or ejectives in other Athabaskan languages. The early work provided me with an invaluable foundation and essential directions to be able to pursue the present study in the first place.

Such important studies include Susan, Russell, and Maria Myers' (2005) *Instructor's Handbook a Guide to Chapters 1 – 3 of E.D. Cook's a Linguistic Instruction to Tsilhqut'in* (Chilcotin), Sharon Hargus' (2007) *Witsuwit'en Grammar: Phonetics, Phonology, Morphology*, Joyce McDonough's (2003) *The Navajo Sound System*, and Sonya Bird's (2002a) "Dakelh Ejectives: Evidence for New Ways of Classifying Sounds."

In particular, without Russell and Myers' enlightening work on Tsilhqut'in, the current study would have had little to refer to or rely on for any information about the language. As will be clear later in the thesis, the work provides basic and essential syntactic, morphological, and phonological information about the Tsilhqut'in language.

Hargus' dedicated work on another Athabaskan language, Witsuwit'en, is used as a framework for this phonetic study to be designed, planned, and implemented, as will be evident, again, in later parts of the thesis. Her phonetic studies, including her collaboration with Richard Wright and Katharine Davis (2002), have enabled me to initiate, refine, and determine how to conduct the current instrumental study. Its methodology is greatly based on the methods that Hargus has developed through years of her work on Witsuwit'en and other Athabaskan languages.

#### **1.4 Outline of the Thesis**

Before moving on to further discussion about the present study, let me give an outline of the remaining chapters in order as an overview of the thesis.

First, in Chapter 2, I will describe what has been found of ejectives across languages. I will give a close look at the traditional typology of ejectives in an effort to understand the current, or any established, theory about the sounds in question. This will also provide the theoretical framework to base the present study on. Then, I will provide a general description of Tsilhqut'in as language background, followed by an overview of the phonetic study that will be given in the last section of the chapter.

In Chapter 3, I will talk about the methodology I have utilized for this phonetic investigation. How the data of the Tsilhqut'in language were collected and organized will first be explained. I will then describe the two major examinations of the study – acoustic analysis and auditory analysis. In the acoustic part, four acoustic properties that were used as the measures of the analysis will be explained with visual illustrations. In the auditory part, I will talk about how I perceived the ejectives in my dataset and how these auditory judgments would be correlated with the acoustic measurements.

In Chapter 4, I will present the results and findings from my instrumental study on ejectives in the Tsilhqut'in language. The chapter will be twofold as the results from the acoustic analysis will be reported first, and those from the auditory analysis will be given next. The first analysis will be presented in two sub-sections since it is composed of two major comparisons. One is to compare stops within the Tsilhqut'in language, and the other is to compare ejectives in different languages.

The next chapter, Chapter 5, includes further in-depth discussions of the results and findings drawn from the entire study. That is, we will discuss the results from the acoustic and auditory analyses more in detail. As mentioned, our further discussion on

the acoustic results will first cover the intra-language comparison and then the inter-language comparison. Some relevant findings from other studies of ejectives across languages will be discussed together for comparison with those from the present study.

Finally, in the last chapter, I will draw general conclusions based on the overall findings from and discussions about this phonetic study of Tsilhqut'in ejectives. I will also address shortcomings as well as the strengths of the study for further follow-up investigations. In other words, I hope that what is found about Tsilhqut'in ejectives through this instrumental study will shed some light on ejective typology and contribute to the linguistic or phonetic field. At the same time, I will feel obliged to remind readers of any issues that the present study raises and that should be considered in future research.

## Chapter Two

### LITERATURE REVIEW

In this chapter, I would like to put my research in context. In Sections 2.1 and 2.2, I will first discuss the ejective typology established by Lindau (1984) and Kingston (1985) and questions it raises. Then, I will provide general background of the Tsilhqut'in language – location, basic linguistic structure, vowel and consonant inventory, and stop classes. In Section 2.3, I will give an overview of the current phonetic study of Tsilhqut'in ejectives.

#### 2.1 Theoretical Context

##### 2.1.1 Ejective Typology and Research Question

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 (Lindau 1984 and Kingston 1985). 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 (Lindau 1984 and Kingston 1985)<sup>5</sup>. Table 1,

---

<sup>5</sup> I thank Dr. Esling for pointing out an issue with these views that they are based on the theory of a vocal tract with a glottis at its base – devoid of a pharynx (constriction mechanism), and that therefore, none of the correlates in Table 1 reflects or account for the resonance of the epilaryngeal tube when the larynx is raised.

which I adapted from Bird 2002a, below summarizes these acoustic correlates found from past work.

**Table 1. Acoustic and Perceptual Correlates of Strong (e.g. Navajo) vs. Weak (e.g. Hausa) Ejectives (adapted from Bird 2002a)**

Correlates	Strong ejectives	Weak ejectives
VOT (Voice Onset Time)	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

However, such a traditional and strict dichotomy of ejectives into strong and weak has given way in recent times to a view that considerable variability exists of ejectives at the phonetic level.

Warner (1996) instrumentally investigated ejectives in Ingush, a Northeast Caucasian language (spoken in Russia), and found that Ingush ejectives do not pattern along the line of the typology. They have acoustic properties that are 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<sup>6</sup>, which is said to be very short for weak ejectives (e.g. Hausa velar ejectives: 25 ms) and long for strong ejectives (e.g. Navajo velar ejectives: 80 ms), was found to be in between for Ingush velar ejectives (50 ms) (p. 1528)<sup>7</sup>.

Wright, Hargus, and Davis (2002) acoustically studied alveolar ejectives in Witsuwit'en, a Northern Athabaskan language, and reported considerable inter-speaker variation. Although mean, or medium, slow rise time, lowered f<sub>0</sub>, and creaky voice quality suggest that the sounds are “slack,” or weak, ejectives (p. 65), there was not one speaker out of eleven exactly fitting into this group categorization. Wright et al. (2002) therefore seem justified in their view that the notion of *average* ejective is “problematic” (p. 69) and that the dichotomous typology is “inadequate” (p. 70) to account for the wide range of the phonetic variation revealed in the production of Witsuwit'en ejectives.

Studying Lheidli, a dialect of Dakelh (Carrier), a Northern Athabaskan language, Bird (2002a) also noted noticeable speaker variation. In production of ejective stops, a single speaker of Lheidli varied between the two types of ejectives. Bird's auditory impressions supplemented with quantified differences in VOT seemed to be in accordance with speaker variation that I also observed with ejectives in Tsilhqut'in, an Athabaskan neighbour of Dakelh<sup>8</sup>. Do ejectives in this language fit into the binary classification or not, then? My research question is as follows:

*Do Tsilhqut'in ejectives pattern as strong or weak, or something in between?*

---

<sup>6</sup> As Dr. Esling points out, I realize that VOT covers time of closure but not force, or strength, of articulation. This is one of the main reasons for my further follow-up research.

<sup>7</sup> Thanks to Dr. Yoon for pointing out that the VOT for velar is usually the longest among places of articulation.

<sup>8</sup> This was my first exposure to the Tsilhqut'in language through a linguistic course (Linguistics Field Methods) offered at the University of Victoria, in spring 2006.

Ultimately, in search of an answer to the question, I decided to conduct an instrumental investigation on these intriguing sounds – the ejectives in Tsilhqut’in.

Before we move onto detailed descriptions of the instrumental study (Chapter 3), I will present in the following section (Section 2.2) general background information about the language under investigation.

## **2.2 General Language Background**

### **2.2.1 Location**

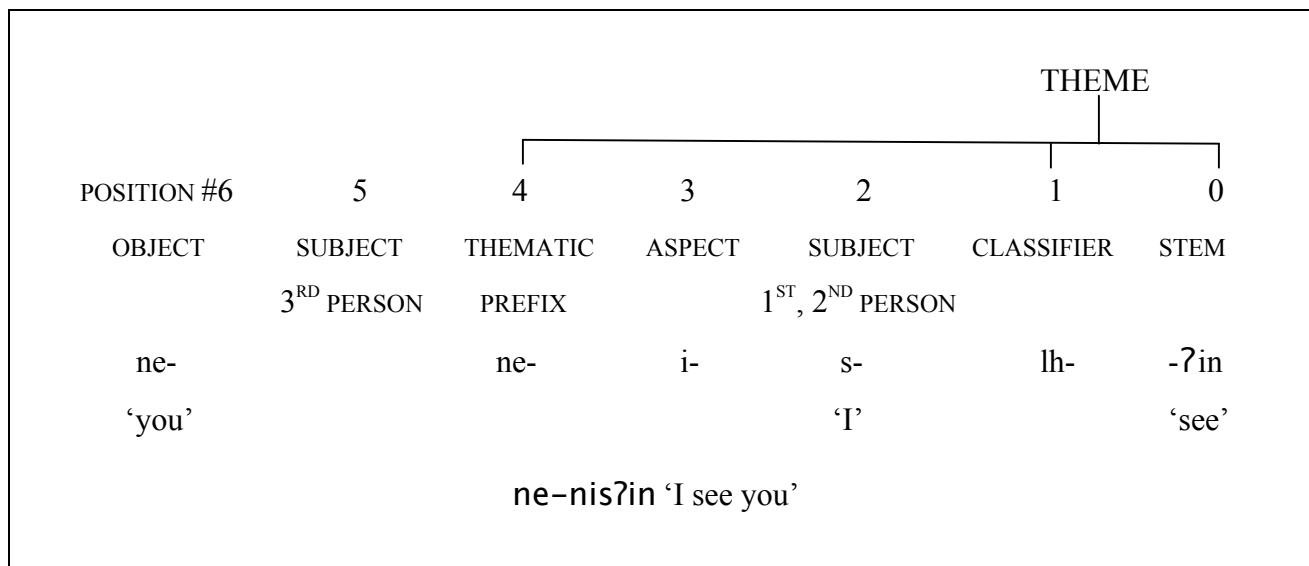
Tsilhqut’in, pronounced [tsɪɫqoʔt’in], is an Athabaskan language spoken in the region between the Tsilhqut’in (Chilcotin) watershed and the Coast Range in the interior of British Columbia, in the vicinity of Williams Lake, along the Chilco and Chilcotin Rivers, Canada. It belongs to the Northern Athabaskan language family, and Carrier is its only Athabaskan neighbour (Lane 1981). Figure 1 below is a map that shows the approximate location of the Tsilhqut’in community, marked as a solid circle.



### 2.2.2 General Information on Linguistic Structure

According to Russell and Myers (2005), Tsilhqut'in is a SOV language in which the verb takes a sentence-final position, following all the rest of the constituents, such as a noun phrase, an adverb phrase, a negation marker, and so forth. The morphology of Athabaskan languages is known to be notoriously complex, and the verbal morphology is particularly crucial in understanding Tsilhqut'in and other languages in the same family. Russell and Myers (2005: p. 34) provide fairly straightforward descriptions of a Tsilhqut'in verbal template as shown in Figure 2.

**Figure 2. Diagram of a Tsilhqut'in Transitive Verb Theme (lh-ʔin 'to see')**



Tsilhqut'in is a tonal language and belongs to the “high-marked” group, like Tanacross, in contrast to “low-marked” languages, such as Tł̥ch̥q̥ Yatì (Dogrib) (e.g. Holton 2000,

Krauss 1975, Rice and Hargus 2005, and Tḥchḳ Yatḥ Multimedia Dictionary 2005).

From my preliminary observation, there seem to be interesting tonal interactions in the Tsilhqut'in language, and I believe the tonal system of the Tsilhqut'in will be extremely worthwhile for close study in the future.

### 2.2.3 Sound Inventory

#### VOWELS

According to Russell and Myers (2005), there are six phonological vowels in Tsilhqut'in, and they are divided into two groups: tense/long vowels (i, a, u) and lax/short vowels (ɨ, e, o). Figure 3 below is adapted from Figure 2: Relative Tongue Position and Tongue Height in Russell and Myers 2005.

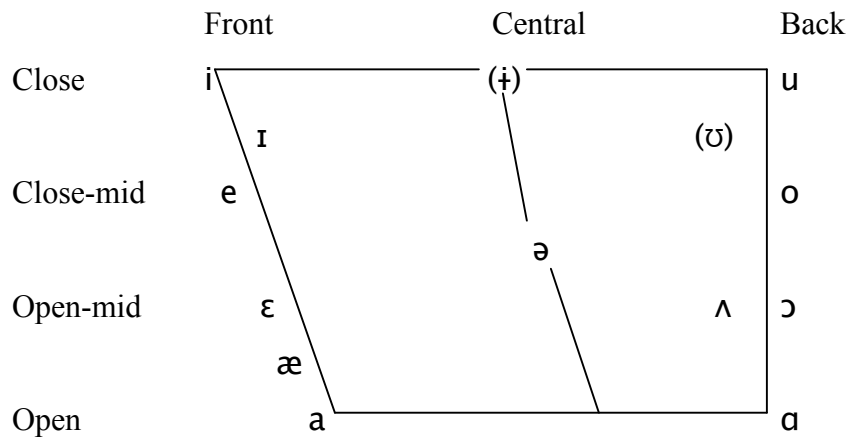
**Figure 3. Vowel Inventory of Tsilhqut'in (orthographic representation)<sup>9</sup>**

	[Front]	[Central]	[Back]
[Close]	i		u
	ɨ		o
		e	
[Open]		a	

<sup>9</sup> These symbols are adopted from Russell and Myers 2005 (i.e., they represent the writing system of Tsilhqut'in).

In my experimental phonetic study<sup>10</sup>, these vowels were observed to be realized as many more refined variations at the phonetic level. An illustration is as follows (Figure 4).

**Figure 4. Vowel Inventory (phonetic representation)**



In addition, nasalized vowels (e.g. [ʃɛ̃n] ‘song’), long vowels (e.g. [sæ:] ‘sun’), diphthongs (e.g. [jəs· hɔ̃jlæ̃n] ‘there is lots of snow’) were also noted in the class elicitations. It remains, however, uncertain at the moment which ones of these vowels are phonemic or allophonic, how they interact in different contexts (e.g. with a certain class of consonants, such as fricatives), and what kind of phonological processes and sound changes take place. Further study of these vowels, again, will yield valuable findings for understanding Tsilhqut’in and other Athabaskan languages.

<sup>10</sup> The preliminary study was a partial requirement for a linguistic course (Fall, 2006). The data used for the acoustic analysis come from a corpus that had been compiled through elicitations with a Tsilhqut’in speaker, Lois William, through another linguistic course (Spring, 2006).

## CONSONANTS

As is typical of many Athabaskan languages, Tsilhqut'in has a rich and complex consonant inventory. As shown in Table 2 below, the inventory 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 (adapted for Tsilhqut'in from Tuttle 1998, Holton 2000, Gessner 2003, and Russell and Myers 2005)<sup>11</sup>**

		Labial	Dental	Lateral	Alveolar	Pharyngealized Alveolar	Alveo-Palatal	Velar	Labialized-Velar	Uvular	Labialized-Uvular	Glottal
Obstruents	Plain	b	d	dl	dz	<u>dʒ</u>	dʒ	g	g <sup>w</sup>	ŋ	ŋ <sup>w</sup>	ʔ
	Aspirated	p	t	tɬ	ts	<u>ts</u>	tʃ	k	k <sup>w</sup>	q	q <sup>w</sup>	
	Ejective		tʰ	tɬʰ	tsʰ	<u>tsʰ</u>	tʃʰ	kʰ	k <sup>wʰ</sup>	qʰ	q <sup>wʰ</sup>	
Fricatives	Voiceless			ɬ	s	<u>s</u>	ʃ		x <sup>w</sup>	χ	χ <sup>w</sup>	h
	Voiced			l	z	<u>z</u>				ʁ		
Sonorants		m	n				j		w		w	

<sup>11</sup> The underline showing with the pharyngealized alveolars and the labialized-uvular denotes pharyngealization (i.e. ʕ).

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 aspirated stop and affricate symbols. Ejective stops and affricates are indicated with apostrophe ('). Therefore, the dental series *d*, *t*, *t'* in orthography, for example, corresponds to [t, t<sup>h</sup>, t'] in IPA. It should also be noted that based on Krauss and Golla (1981), there is ambiguity whether the fricatives written as *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 with here.

#### 2.2.4 Stop Series

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 the acoustic analyses and comparisons of the current study. In other words, labial and glottal stops *b*, *p*, and *ʔ* were excluded from the investigation since they are not in a full three-way distinction as the rest of the stops are.

It is the third type of stops, hereafter referred to as *ejectives*, which is the focus of the comparisons.

### 2.3 Overview of the Phonetic Study

Recall that the current study was motivated from the research question – *Do Tsilhqut'in ejectives pattern as strong or weak, or something in between?* This study was set out to find out whether or not Tsilhqut'in ejectives would be in accordance with the dichotomous categorization of ejectives: *strong* vs. *weak*, established through previous work (e.g. Lindau 1984 and Kingston 1985). As discussed earlier, some traits found to be correlated with the strong ejectives are long VOT, modal or tense voice, a raised pitch and a sudden intensity increase from the voicing onset to the peak of a post-stop vowel, whereas the weak ejectives have such phonetic characteristics as short VOT, creaky voice, lowered pitch and a gradual amplitude raise from the voicing onset to the peak of the following vowel.

These acoustic correlates provide a basis for the current study. That is, in order to analyze acoustically and determine how the Tsilhqut'in ejectives pattern in relation to this binary classification, such correlates were selected to be the measures of the present investigation: VOT, Jitter Perturbation, F0 Perturbation, and Rise Time. Table 3 below summarizes the selected correlates.

**Table 3. Four Acoustic Measures for the Present Study**

Correlates	Strong	Weak
VOT ( <i>VOT</i> )	long	short
Voice quality ( <i>Jitter Perturbation</i> )	modal or tense	creaky
Pitch at voicing onset ( <i>F0 Perturbation</i> )	raised	lowered
Amplitude at voicing onset ( <i>Rise Time</i> )	sudden increase	gradual increase

To give a brief overview, the first measure *VOT*, voice onset time, is the period between the burst of an ejective and the onset of the voicing of a vowel following the ejective; the second *Jitter Perturbation*, is used to determine voice quality of the same vowel; and the third *F0 Perturbation* and the fourth *Rise Time*, are used to determine pitch and amplitude of the post-ejective vowel, respectively<sup>12</sup>. These four measures were chosen for the present study because they have been used in other studies of ejectives and found to show acoustic features distinctive to the ejectives in comparison with other types of stops (e.g. McDonough and Ladefoged 1993, Warner 1996, Wright et al. 2002, and Hargus 2007). *VOT* is an acoustic feature commonly used in comparing not only 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 a stop compose a large part of the whole phonetic nature of stops (e.g. Lindau 1984, Kingston 1985, Warner 1996, and McDonough 2003).

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<sup>12</sup> For detailed descriptions of the measures, see Section 3.4, Chapter 3.

Referring to the ejective articulation that we discussed earlier (Chapter 1), it can be appreciated why VOT, voice quality, pitch, and amplitude are frequently chosen to be prime measures of a phonetic study of ejectives. In other words, as Warner (1996) explains clearly, due to the closed glottis during the burst of an ejective, the unusually high air pressure in the oral cavity, and the raised larynx, we would expect the ejective to have distinctive phonetic characteristics from those of a pulmonic stop with a different mechanism of articulation<sup>13</sup>.

For instance, its voice quality or phonation type (i.e. the action of the vocal cords) at the beginning of a post-ejective vowel should be different from that of a vowel following a non-ejective stop. During the articulation of an ejective, the vocal cords are held tightly together, whereas they are apart or loosely closed during a non-ejective stop. This difference in the vocal cord action should also result in further difference in the pitch of the vowel following the two types of stops. In addition, the very high pressure created in the oral cavity will undoubtedly affect the rise of the amplitude from the voicing onset to the peak of the post-ejective vowel, therefore making it distinctive from that of the vowel after a pulmonic stop<sup>14</sup>. Furthermore, by this unique mechanism of ejective articulation, VOT and other duration measures should be influenced and are likely to be different from those of the other stops.

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<sup>13</sup> This is because the size of the pharynx reduces when the glottis is closed and the larynx raises (thanks to Dr. Esling for the input).

<sup>14</sup> In addition, according to Dr. Esling, there seems to be constriction of the pharyngeal vocal tract during the (pharyngeal) tightening for an ejective (Again, my gratitude to Dr. Esling for the insights. I believe this is the one of the areas for me to follow up on by further research in the near future).

I completely agree with Warner (1996) that it is extremely important for us to examine ejectives from many different languages and find out how the acoustic characteristics pattern from one language to another (p. 1525).

The next chapter, Chapter 3, describes in detail how the Tsilhqut'in stops were instrumentally analyzed. That is, the chapter provides descriptions of how the four measures were obtained and how the ejectives then were phonetically described in comparison to the other types of stops. This instrumental study will shed light on the questions raised in this chapter: what are the acoustic properties of the Tsilhqut'in ejectives? Do they pattern along the lines of the traditional *strong-weak* typology?

## Chapter Three

### METHODS

In this chapter, I will talk about the methodology used in the current phonetic study of ejective and non-ejective stops in Tsilhqut'in. Section 3.1 outlines the research questions of the study, and Section 3.2 describes two resources that provided the data for the study. Section 3.3 explains how each of the collected stop tokens was segmented so that a spectral examination could be conducted. The descriptions of the spectral analysis are given in the following section (Section 3.4) with four subsections providing further details of the four acoustic measures – VOT, Jitter Perturbation, F0 Perturbation, and Rise Time, respectively. In the last two sections, I will talk about normalization of these measures (Section 3.5) and an impressionistic analysis conducted to compare my auditory judgments and the acoustic characteristics of the ejectives (Section 3.6).

#### 3.1 The Phonetic Study

As mentioned in the previous chapters, the present study aims to investigate instrumentally the Tsilhqut'in ejectives, to verify the initially observed phonetic variability of these intriguing sounds, and to see if results of the study also support the need for the traditional binary typology of ejectives to be reconsidered. The research question that I stated earlier is *Do Tsilhqut'in ejectives pattern as strong or weak? Or something in between?* In order to answer the question, acoustic properties of the

ejectives needed to be determined. Accordingly, in an attempt to find a way to describe Tsilhqut'in ejectives phonetically, two major comparisons were implemented as shown in the following.

- 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, Athabaskan and non-Athabaskan, languages

Descriptions of the data used for these comparisons follow in the next section.

### **3.2 Data**

The data used in this study come 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 (Spring 2006). The 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<sup>15</sup> CD created at the Center for Comparative Psycholinguistics, University of Alberta in July 2004<sup>16</sup>. The original copy of the CD, containing a list of 142 common words, was prepared by Maria Myers and 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<sup>17</sup>.

From these corpora, 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., 1989). Two tables below are a partial token list as an example (Table 4) and a summary of the dataset (Table 5)<sup>18</sup>.

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15 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, and has been used for indigenous and African language studies as an inventory evaluation tool.

16 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.

17 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.

18 A full list of ejective tokens are shown in APPENDIX.

**Table 4. Partial List of Tokens: Ejectives in Tsilhqut'in<sup>19</sup>**

Token	Orthography	Transcription	Gloss
/tʰ/			
1	nenededī(n)lht'i	nəndɛnədɪtʰɛɪ	s/he closed the entrance (door, gate)
2	nenededī(n)lht'i	nændænædɪltʰi:	s/he closed the entrance (door, gate)
3	xents'agughelht'ih	xənts'ægowətʰi	you (pl.) prayed
4	xents'agughelht'ih	xənts'ægo:tʰih	you (pl.) prayed
5	jiʔadest'in	dʒiʔədɛst'in	I began
6	jiʔadest'in	dʒiədɛst'in	I began
7	hunilht'ah	huniɪtʰæh	how are you?
8	set'a	sɛ'tʰæ:	my wings
9	seʔanest'ih	səʔænɪs'tʰih	I'm doing well
/tsʰ/			
10	belhadelhts'ish	bətʰədətʰsʰɪç	s/he/it is yawning
11	belhadelhts'ish	bətʰədɛtʰsʰɪç	s/he/it is yawning
12	hi(n)lhts'ugh	xiɪtsʰao:	you (sg.)/I mixed it (liquid batter)
13	hi(n)lhts'ugh	hiɪtsʰo:γ	you (sg.)/I mixed it (liquid batter)
14	belhadeʒinlhts'ish	bɪɪədətʰɛjɪtsʰeɪh	you yawned
15	belhadeʒinlhts'ish	bɪɪədətʰɛjɪtsʰeɪh	you yawned

<sup>19</sup> Note that of the diacritics seen in the table, [̃] denotes nasality of a vowel; [ˈ] and [ˌ] denote a primary stress and a secondary stress, and [ˊ], [ˋ], and [ˊˋ] denote high tone, low tone, and a rising tone in the language.

**Table 5. Token Counts: Plain, Aspirated, and Ejective stops across 9 Places of Articulation**

		Dental	Lateral	Alveolar	Pharyngealized Alveolar	Alveo-Palatal	Velar	Labialized-Velar	Uvular	Labialized-Uvular	Total
Stops	Plain	d	dl	dz	<u>d̥z</u>	dʒ	g	g <sup>w</sup>	ŋ	ŋ <sup>w</sup>	<b>106</b>
		49	10	11	0	15	17	4	0	0	
	Aspirated	t	tɬ	ts	<u>t̥s</u>	tʃ	k	k <sup>w</sup>	q	q <sup>w</sup>	<b>80</b>
		30	0	17	2	7	2	4	16	2	
	Ejective	t'	tɬ'	ts'	<u>t̥s'</u>	tʃ'	k'	k <sup>w'</sup>	q'	q <sup>w'</sup>	<b>43</b>
		9	3	9	0	7	6	4	5	0	
<b>Total</b>		<b>88</b>	<b>13</b>	<b>37</b>	<b>2</b>	<b>29</b>	<b>25</b>	<b>12</b>	<b>21</b>	<b>2</b>	<b>229</b>

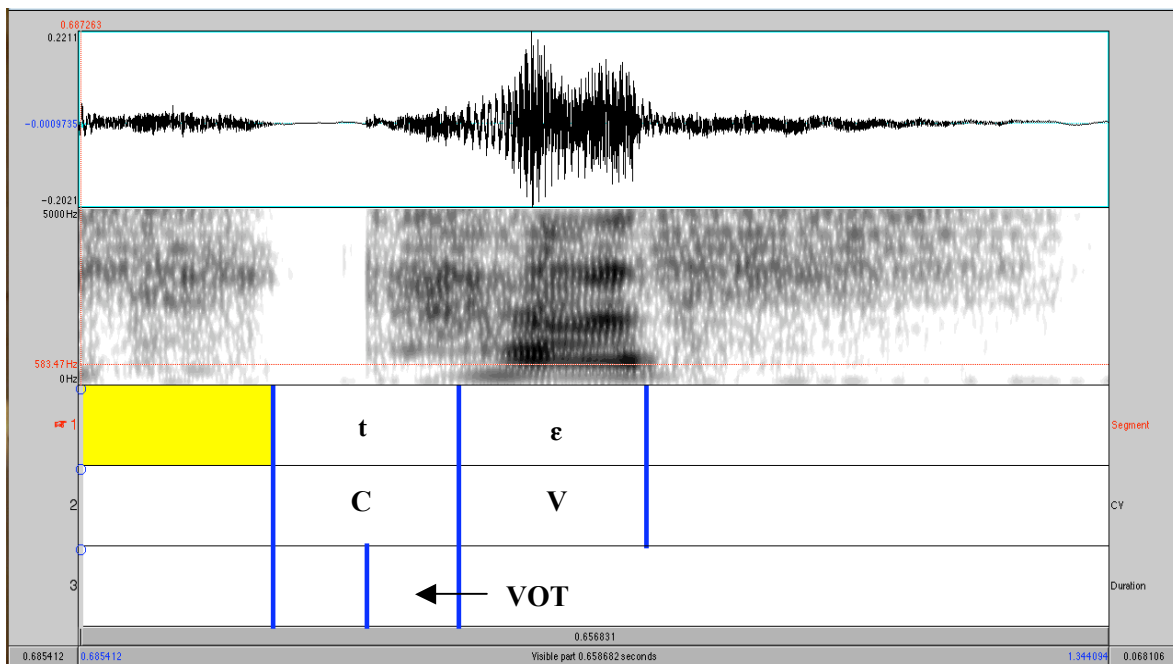
The morphological control of the tokens to be uniformly “stem-initial” in fact bears significance since past work has shown the importance of morphology in affecting the phonetic features of Athabaskan languages (Tuttle 1998, Holton 2000, Gessner 2003, McDonough 2003, Bird 2004, Rice and Hargus 2005, 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, since it was impossible to detect onset of a stop closure by using Praat<sup>20</sup>. It should also be noted that the number of tokens is quite small and that there is also an unevenness in token counts. I realize that these are two of the main limitations of the current study.

<sup>20</sup> Praat is speech analysis software that has been developed by Paul Boersma and David Weenink since 1992.

### 3.3 Segmenting

To begin the instrumental investigation, each of 229 tokens was segmented and annotated by using Praat (version 4.4.03). That is, boundaries were placed around each of a stop (C) and a following vowel (V). Each stop (C) was further divided into 2 periods: closure and VOT. Figure 5 below illustrates the segmentation.

**Figure 5. [tɛ] as in [jədɛni+tɛɪ] '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.

### 3.4 Spectral Examination

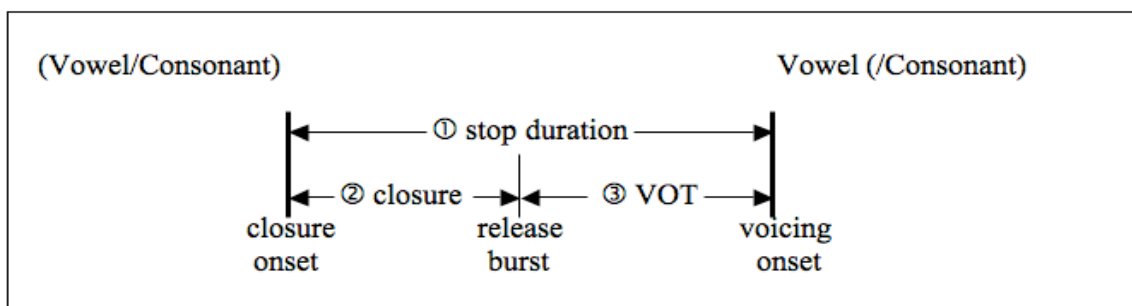
As Praat has a scripting function, I had written a script in such a way that it could take from the segmented elements (i.e. C, V, and VOT) 4 measures: Duration, Jitter Perturbation, F0 Perturbation, and Rise Time. I visually examined the waveform and spectrogram of each token and made sure if the script was taking the measurements correctly 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.

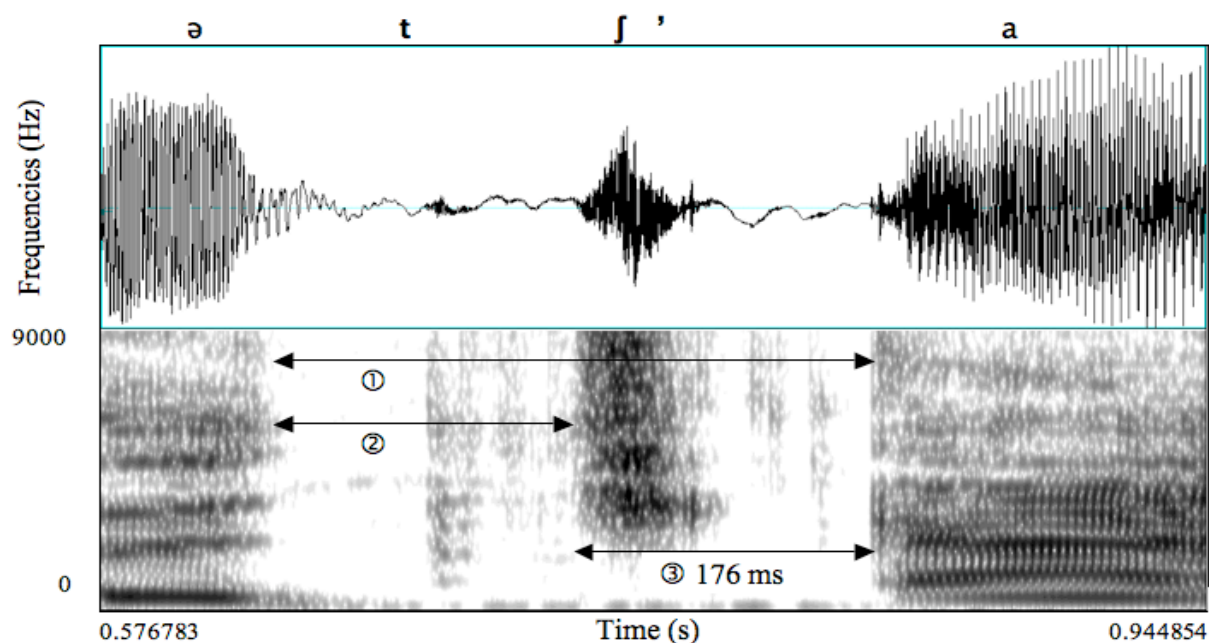
#### 3.4.1 VOT

A stop is 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 in this study is the duration of such a period that is marked as ③ in Figure 6 and Figure 7 below.

**Figure 6. Schematic Diagram of Duration and Timing of Ejectives (adapted from McDonough 2003)**



**Figure 7. VOT: [ətʃ'a] as in [sətʃ'an] 'before me (as in "before my time"))'**



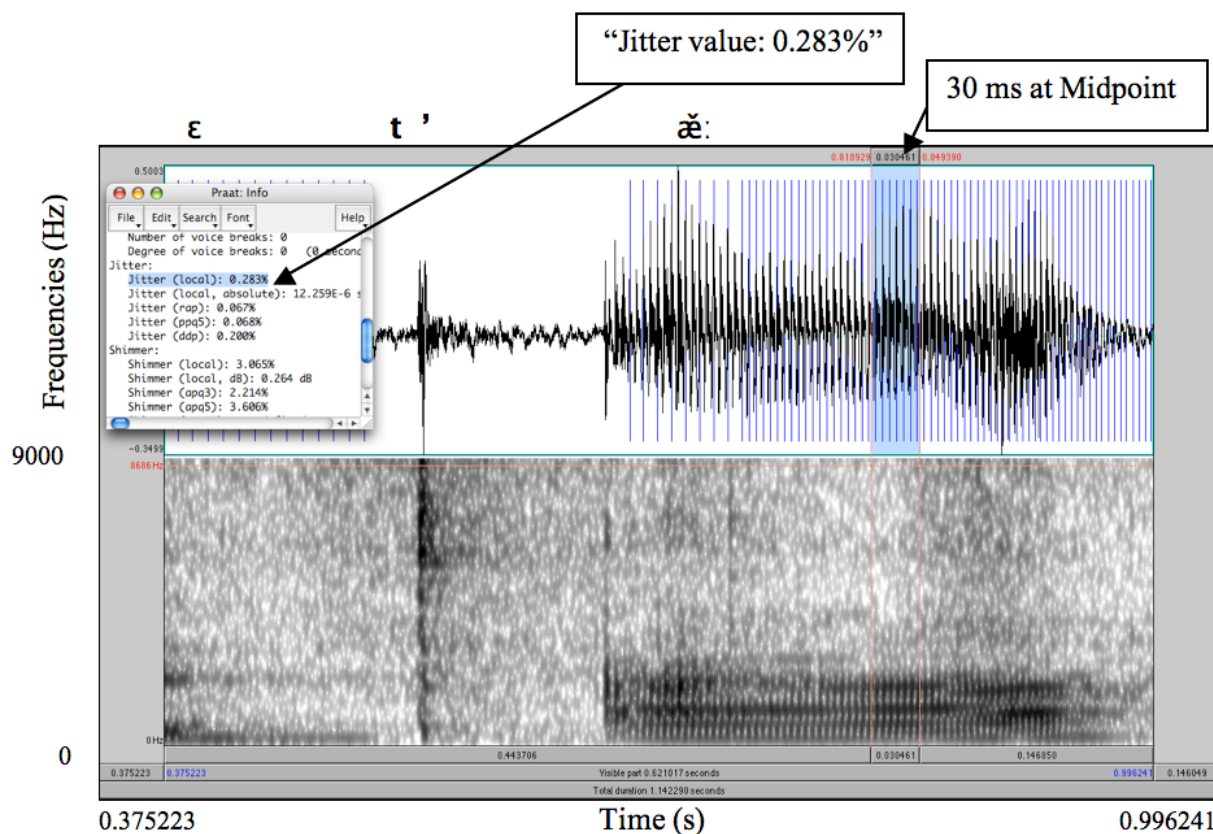
As seen, the alveo-palatal ejective [tʃ'] in Figure 5 above had VOT of 176 ms.

### 3.4.2 Jitter Perturbation

Jitter Perturbation measures a degree of aperiodicity (i.e. irregularity of the pitch pulses) of a vowel after a stop. This acoustic cue, often together with other acoustic correlates, such as spectral noise, is used to distinguish between different phonation types. Creaky voice, for example, typically yields jitter values higher than those of modal or breathy

voice (Kent and Read 2001). For the current investigation, I took jitter measurements for the duration of 30 ms windows of the following vowel of every token at two points: at the onset of the voicing and at the midpoint<sup>21</sup>. Figure 8 below provides an example of a jitter value (0.283%) taken from a 30 ms window at the midpoint of the vowel [æ:] following the dental ejective [tʰ].

**Figure 8. Jitter Perturbation: [ɛ'tʰæ:] as in [sɛ'tʰæ:] ‘my wings’**

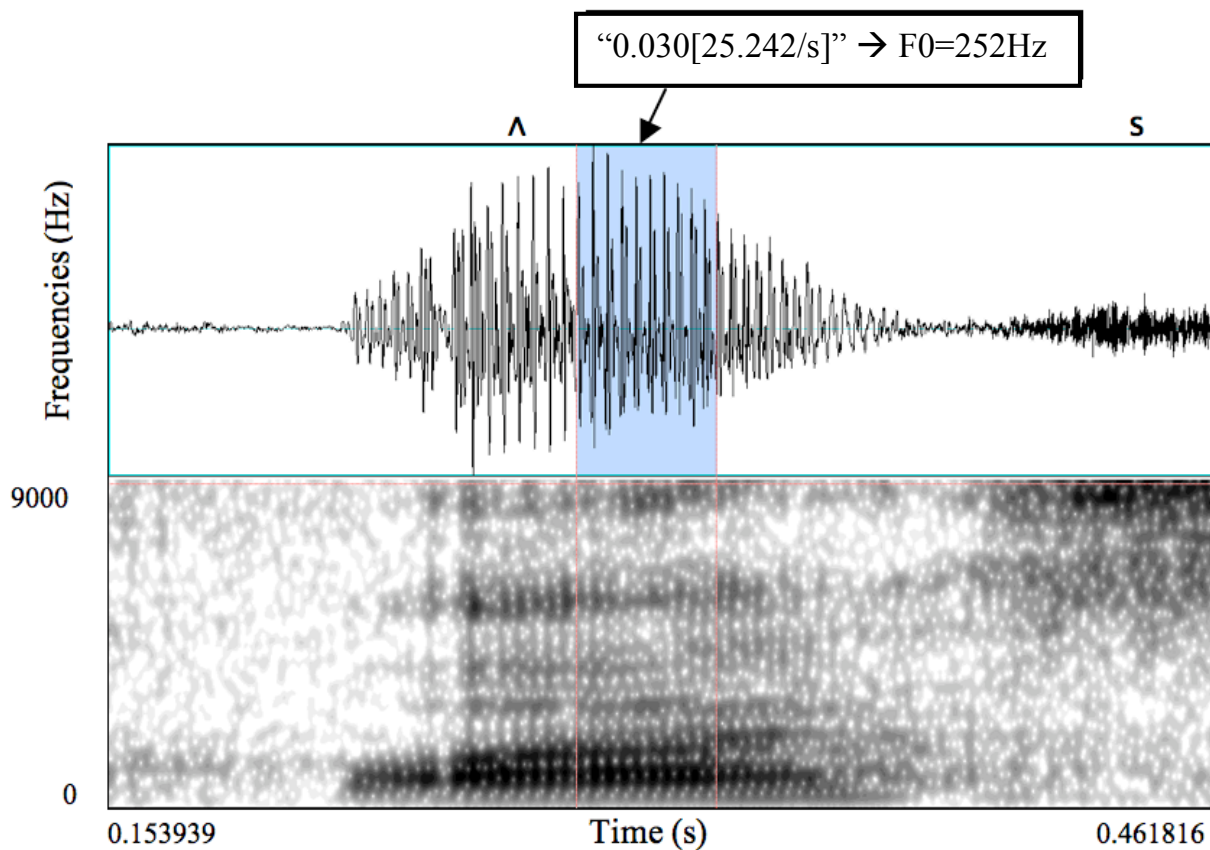


<sup>21</sup> So that I could follow the methodology used in the previous studies of Witsuwit'en stops by Wright, Hargus, and Davis (2002) and by Hargus (2007), I am grateful to Dr. Sharon Hargus for sending me a copy of such invaluable work even before its publication. I also appreciate Dr. Yoon's point that this way of measuring Jitter Perturbation may not be reliable because resulting measurements can be seriously affected by pitch period that the 30ms-windowed signal contains.

### 3.4.3 F0 Perturbation

F0 Perturbation is employed to see if there is any change or difference in pitch from voicing onset to the midpoint of a vowel and to determine how big the difference is, if any. That is, in this instrumental study, 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 difference between the points was calculated. Figure 9 below illustrates how F0 (252 Hz) was obtained from the 30 ms window at the midpoint of the vowel [ʌ] after the labialized-velar ejective [kʷ].

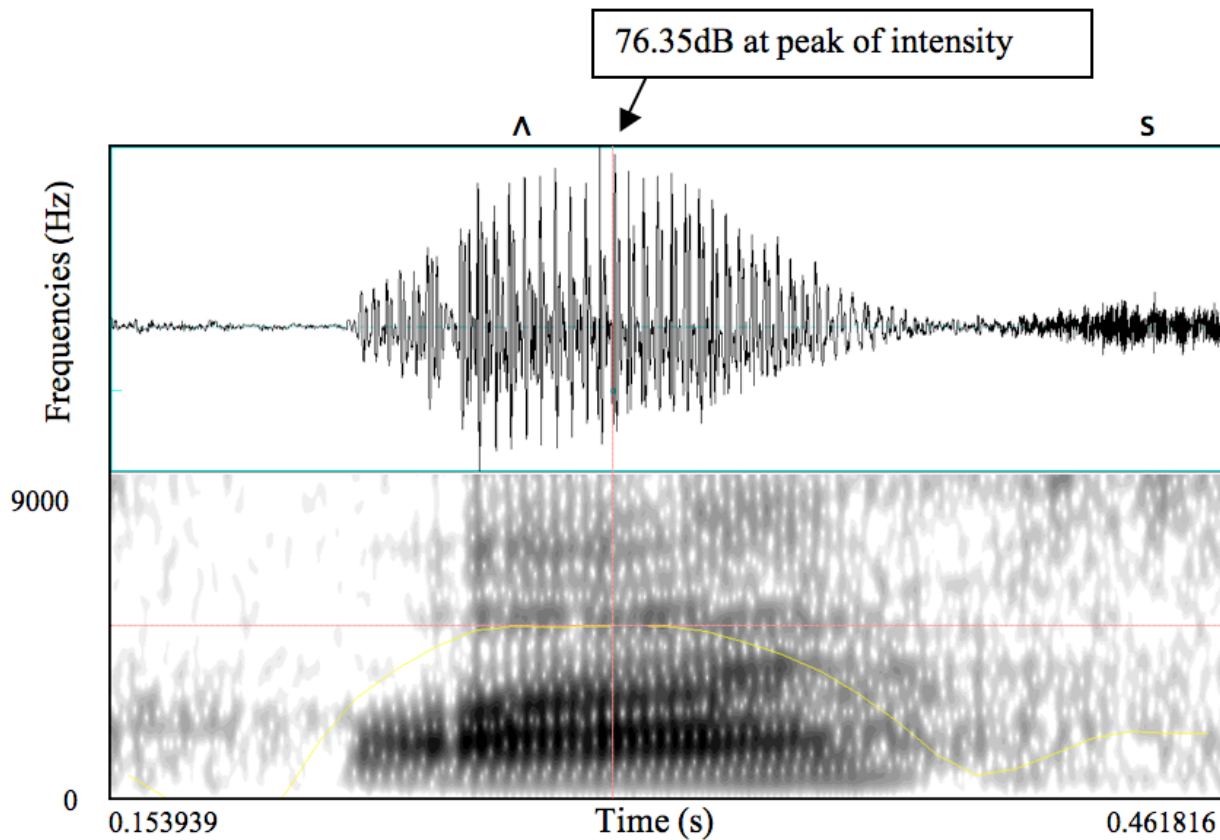
**Figure 9. F0 Perturbation: [ʌs] as in [kʷʌs] ‘cloud’**



#### 3.4.4 Rise Time

Rise Time, also called “energy” (Hargus 2007), is used to measure a degree of intensity (or amplitude) in a vowel following a stop. Intensity values for the present study were taken at 3 points - at the voicing onset, 30 ms later, and the peak of a post-stop vowel. Although these values showed an overall amplitude pattern, rise time in this study is defined as “the difference between energy at vowel peak and energy at 30 ms after vowel onset” (Hargus 2007: p. 80). 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 vowel after a stop. According to Hargus (2007), the intensity differences between these two periods were found to be the greatest between ejective and non-ejective stops in Witsuwit'en, a Northern Athabaskan language, indicating the former had a *slower rise* to the maximum energy than the latter (p. 80). In other words, such a difference in amplitude between the two points separates ejectives from the other stops. The example in Figure 10 below had 76.35 dB at the peak intensity.

**Figure 10. Rise Time: [ʌs] as in [kʷʌs] ‘cloud’**



To summarize, of the four correlates in this phonetic study, VOT (ms) is used to measure the duration between the release of the burst of the stop and the voicing onset of the following vowel; Jitter Perturbation (%), a degree of aperiodicity, or phonation types; F0 Perturbation (Hz), difference in pitch; and Rise Time (dB), a degree of intensity, or energy, in a vowel following a stop.

### 3.5 Normalization

Based on the model used in the two Witsuwit'en studies (Wright et al. 2002 and Hargus 2007), the measures of Jitter Perturbation, F0 Perturbation, and Rise Time were normalized. The formulas for the normalization are shown in Table 6 below.

**Table 6. Normalization of Acoustic Measures<sup>22</sup>**

<b>Jitter Perturbation</b>	mean Jitter at onset of voicing – mean Jitter at vowel midpoint
<b>F0 Perturbation</b>	mean F0 at onset of voicing – mean F0 at vowel midpoint
<b>Rise Time</b>	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).

However, since the current phonetic study had a very small number of tokens, this method of normalization could not sufficiently get rid of the inter-speaker variability. Therefore, an additional way of normalizing the data, called *z-score* (Glass and Hopkins 1995)<sup>23</sup>, was employed. With the mean,  $\mu$ , and standard deviation,  $\sigma$ , calculated, each individual value could be described relative to the entire set of the measurements for each measure (p. 83). For example, if mean VOT is 100 ms (i.e.  $\mu=100$ ) and standard deviation is 10 ms (i.e.  $\sigma=10$ ), a VOT measurement of 120 ms can be interpreted as a *z-score* of 2, meaning the value is 2 standard deviations *above* the mean – or the centre – of *zero*, while another VOT measurement of 80 ms will be transformed to a *z-score* -2 as it is 2 standard deviations *below* the mean of 0. The equation of the *z-score* is provided in Table 7 below.

<sup>22</sup> Adapted from Wright et al. 2002 (Table 7).

<sup>23</sup> Be advised that the method of *z-score* was taken from Glass and Hopkins 1995.

**Table 7. Z-Score: the Standard Normal Distribution as a Standard Reference Distribution (adapted from Glass and Hopkins 1995: p. 83)**

Z-Score ( $z_i$ )	$z_i = (X_i - \mu) / \sigma$
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### 3.6 Auditory Analysis

As I mentioned earlier, my initial perception of the Tsilhqut'in ejectives during the linguistic course varied substantially. In other words, to my Korean ears, the ejectives sometimes sounded strong and clear, whereas they, in other times, were less clear and softer or even lenis, sounding more like fortis, or laryngealized, stops in Korean (e.g. the alveolar fortis stop in 딸 [t<sup>h</sup>al] 'daughter' in contrast to its counterpart aspirated and plain stops, 탈 [t<sup>h</sup>al] 'mask' and 달 [tal] 'moon or month,' respectively)<sup>24</sup>.

Accordingly, to learn more about this perceptual variability, I decided to expand the present investigation by supplementing an auditory analysis. That is, in order to see if there would be any correlation between my perception and phonetic characterization of the ejectives, I compared the results of the acoustic measurements with my auditory judgments of the sounds. Descriptions of the auditory analysis and the comparison are as follows.

I listened to each sound file of 43 ejective tokens on my computer, Mac OS X Version 10.4.10, multiple times and then encoded my perception of each ejective as 1 (for strong), 2 (for weak), or 3 (for uncertain, that is, combination of both strong and

<sup>24</sup> Note that the superscripted single-quotation sign here is not to mark the alveolar as an ejective but as a fortis stop since there is no conventionalized IPA symbol to denote such stops in languages like Korean. See *Handbook of the International Phonetic Association* for an illustration of the Korean sound system (pp. 120-123)

weak) in an SPSS file. Then, to find out if my perceived impressions of the sounds in any way correlated to their acoustic characteristics, I compared the results of my auditory perception to the measurements of VOT, Jitter Perturbation, F0 Perturbation, and Rise Time, previously obtained from the acoustic analysis. In other words, those tokens grouped as strong in my perception (1), for example, were examined in terms of their duration, voice quality, pitch, and intensity to see if they showed any correlative pattern such as long VOT, modal voice, raised F0, and great amplitude, characteristic of strong ejectives according to the traditional binary classification.

In the following Chapter 4, I will present what findings and results were drawn from these acoustic and auditory analyses.

## **Chapter Four**

### **RESULTS**

In this chapter, I will present results and findings from the present instrumental study of ejective and non-ejective stops in Tsilhqut'in. The chapter is twofold. The first part is composed of the results taken from the acoustic examination (Section 4.1), and the second part, of the results taken from the auditory analysis (Section 4.2), as described in the previous chapter. The first section is further divided into two sub-sections, presenting what was found of the comparison among stops in the Tsilhqut'in language and of the comparison among ejectives across languages, respectively.

#### **4.1 Acoustic Analysis**

##### **4.1.1 Intra-language Comparison**

In this section, I will present measurement results of VOT, Jitter Perturbation, F0 Perturbation, and Rise Time from the acoustic analysis. The analysis was made to determine the phonetic characteristics of the ejectives by comparing them with plain and aspirated stops in the language. The values of each of the measures were first compared among the three stop groups. They were then analyzed further by using Univariate Analysis of Variance and Post Hoc Tests in order to see whether or not differences, if any, were statistically significant. These statistics were conducted on both averaged

values and z-normalized measurements for every measure<sup>25</sup>. Detailed descriptions of these results follow next.

Firstly, overall results from mean VOT, together with mean closure duration and mean stop duration (that is, the sum of closure and VOT duration)<sup>26</sup>, are summarized in Table 8 below.

**Table 8. Mean Duration across 3 Stop Groups<sup>27</sup>**

	Closure (ms)	VOT (ms)	Stop (ms)
Plain	76 (45)	<b>46 (45)</b>	122 (72)
Aspirated	78 (49)	<b>105 (47)</b>	183 (76)
Ejective	67 (48)	<b>102 (54)</b>	155 (77)

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

As mentioned earlier, the statistical analysis by using Univariate Analysis of Variance and Post Hoc Tests (Tukey) was carried out to see if the distinction between the plain group and the other two stop groups combined was significant. According to the

<sup>25</sup> For details about the two normalization methods, refer to Chapter 3.

<sup>26</sup> Notice that in case of the ejectives, the sum of the Closure duration and the VOT does not equal to the whole Stop duration (i.e.,  $67 + 102 \neq 155$ ). It is because 12 out of 43 ejective tokens were word-initial and thus could only be measured for VOT, not for the other two durations. In other words, 67 ms and 155 ms are mean Closure duration and mean Stop duration of 31 ejectives, respectively, while 102 ms is mean VOT of 43 ejective tokens (see section 2.1).

<sup>27</sup> In the table, values in the parentheses are standard deviation (SD).

results as shown in Table 9 and Table 10 below, this difference was confirmed to be statistically significant ( $\alpha = 0.05$ )<sup>28</sup>.

**Table 9. Results of Univariate Analysis of Variance and Post Hoc Tests: Mean VOT<sup>29</sup>**

		Mean Difference (I-II)	Standard Error	P-value ( $\alpha = 0.05$ )
Stop I	Stop II			
plain	aspirated	-59.86	7.01	< 0.001*
plain	ejective	-56.57	8.55	< 0.001*
aspirated	ejective	3.29	8.95	0.92

**Table 10. Results of Univariate Analysis of Variance and Post Hoc Tests: Z-normalized VOT**

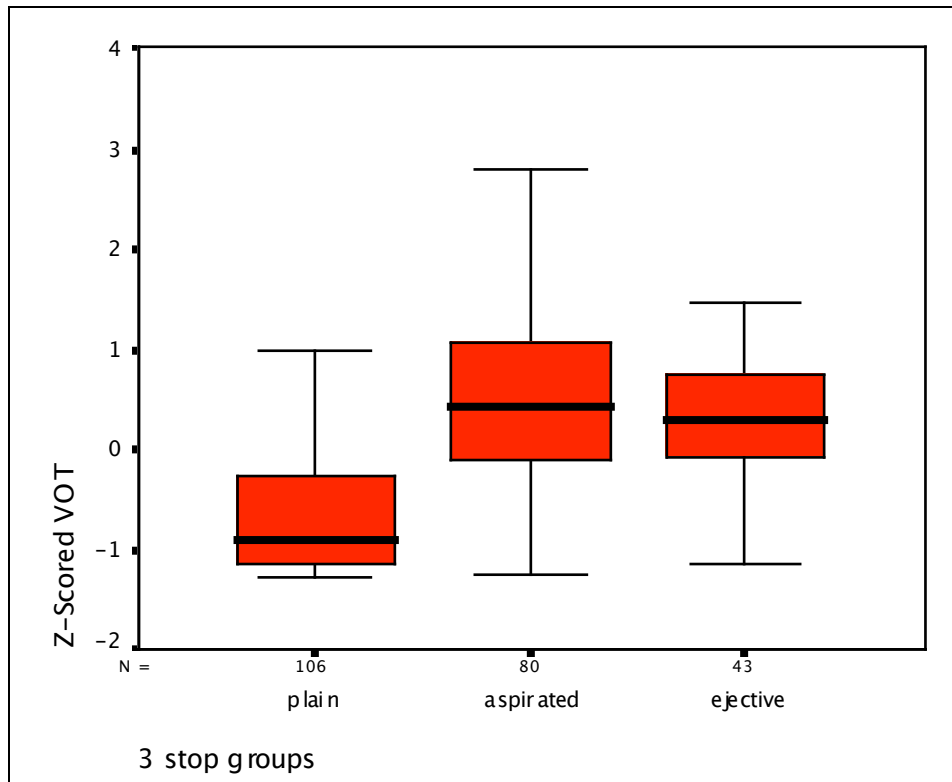
		Mean Difference (I-II)	Standard Error	P-value ( $\alpha = 0.05$ )
Stop I	Stop II			
plain	aspirated	-1.07	0.12	< 0.001*
plain	ejective	-1.01	0.15	< 0.001*
aspirated	ejective	0.06	0.16	0.92

<sup>28</sup> The mean difference is significant at 95% confidence level (or  $\alpha = 0.05$ ).

<sup>29</sup> An asterisk (\*) next to the p-value in this table and the rest of the tables in the thesis indicates significance.

The following boxplot chart highlights this contrast between the plain and the other stops<sup>30</sup>.

**Chart 1. Z-normalized VOT across 3 Stop Groups**



As illustrated above, the mean VOT values of the aspirated and ejective stops range between 0 (= centre) and 1, while the mean VOT values of the plain stops range from 0 to -1<sup>31</sup>. That is, the VOT results show that the aspirated stops and ejectives formed a similar pattern different from the other plain stops.

<sup>30</sup> Outliers in Chart 1 and the rest of the charts in this chapter are not shown.

<sup>31</sup> In this chart and the remaining boxplot charts in the thesis, only the range within each box, not the whiskers shown outside the boxes with solid lines, is discussed.

To sum up, in terms of VOT, the data from the Tsilhqut'in stops used in this study revealed a statistically significant contrast between the plain stops and the aspirated and ejective stops.

Second, mean Jitter values obtained from the entire dataset are shown in Table 11 below.

**Table 11. Mean Jitter Perturbation across 3 Stop Groups<sup>32</sup>**

	Jitter: V onset (%)	Jitter: V mid (%)	Jitter Perturbation: V onset - mid (%)
Plain	2.0 (1.5)	0.6 (0.4)	<b>1.4 (1.5)</b>
Aspirated	2.3 (1.6)	1.1 (3.5)	<b>1.2 (3.9)</b>
Ejective	3.8 (3.0)	1.2 (1.5)	<b>2.5 (3.4)</b>

As indicated by the “Jitter: V onset” and “Jitter Perturbation: V onset – mid” figures, among the three stops, the ejectives showed the highest initial Jitter (mean 3.8%, SD 3.0%) and the biggest decrease towards the following vowel midpoint (mean 2.5%, SD 3.4%). This finding points to the direction that they are *weak* ejectives.

The statistical results summarized in Table 12 and Table 13 below showed that the difference (of the voicing onset – vowel midpoint) between the ejective and non-ejective stops in Tsilhqut'in is significant.

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<sup>32</sup> In the table, values in the parentheses are standard deviation (SD).

**Table 12. Results of Univariate Analysis of Variance and Post Hoc Tests: Mean Jitter Perturbation**

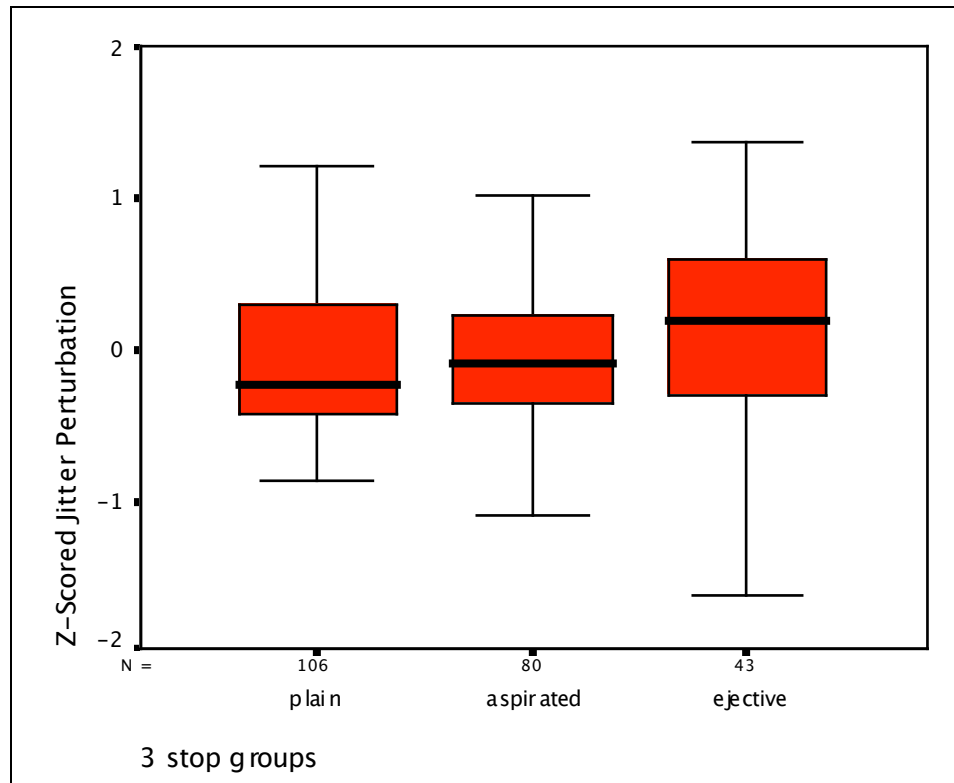
		Mean Difference (I-II)	Standard Error	P-value ( $\alpha = 0.05$ )
Stop I	Stop II			
plain	aspirated	0.16	0.42	0.91
plain	ejective	-1.17	0.52	0.06
aspirated	ejective	-1.33	0.54	0.03*

**Table 13. Results of Univariate Analysis of Variance and Post Hoc Tests: Z-normalized Jitter Perturbation**

		Mean Difference (I-II)	Standard Error	P-value ( $\alpha = 0.05$ )
Stop I	Stop II			
plain	aspirated	0.05	0.14	0.91
plain	ejective	-0.40	0.17	0.06
aspirated	ejective	-0.45	0.18	0.03*

As shown, the Jitter difference between the ejectives and the aspirated stops was confirmed to be significant, and the difference between the ejectives and the plain stops is approaching statistical significance ( $p = 0.06$ ). Boxplot illustrates these findings.

**Chart 2. Z-normalized Jitter Perturbation across 3 Stop Groups**



Although the difference between the ejective and plain stops is not absolutely statistically significant, it appeared to be big enough to distinguish one from the other. Where the boxes are plotted (i.e., the ranges of the Jitter measurements) in the chart seems to show that the plain stops pattern similarly to the aspirated stops, but differently from the ejectives.

In short, regarding the Jitter, or acoustic measures related to the voicing quality, of the post-stop vowels, the data in the current study shows that a two-way distinction can be made between the ejectives and the other stops in the Tsilhqut'in language.

Third, overall results of F0 Perturbation measurements are shown in Table 14.

**Table 14. Mean F0 Perturbation across 3 Stop Groups<sup>33</sup>**

	F0: V onset (Hz)	F0: V mid (Hz)	F0 Perturbation: V onset - mid (Hz)
Plain	218 (31)	211 (30)	<b>8 (23)</b>
Aspirated	224 (34)	215 (32)	<b>8 (16)</b>
Ejective	209 (45)	214 (33)	<b>-5 (38)</b>

Compared to the other stops, the ejectives had the lowest pitch at the voicing onset, or “F0: V onset,” (mean 209Hz, SD 45Hz) and then the increase into the midpoint of the post-stop vowel, or “F0 Perturbation: V onset – mid,” (mean -5Hz, SD 38Hz). On the other hand, the vowels following the non-ejective stops dropped their pitch from the voicing onset to the midpoint. The increase in pitch of a vowel after an ejective is another indication that the Tsihqut’ in ejectives may be *weak*.

In addition, it is interesting to see the results of the Jitter and F0 Perturbation agree here as creaky voice and pitch sometimes go together such that creaky voice has low F0)<sup>34</sup>. The figures of the two measures from this study showed that the ejectives have the highest Jitter Perturbation, or the greatest aperiodic, values. This means that they, in their quality of voicing, have more creakiness than the plain and aspirated stops.

<sup>33</sup> In the table, values in the parentheses are standard deviation (SD).

<sup>34</sup> Esling (2005) shows that a CV + ejective sequence and nasalized V and pharyngeal tightening correlate with engagement of the laryngeal constrictor.

In what follows, Table 15, Table 16, and Chart 3 show that the F0 Perturbation makes the ejectives distinct from other types of stops.

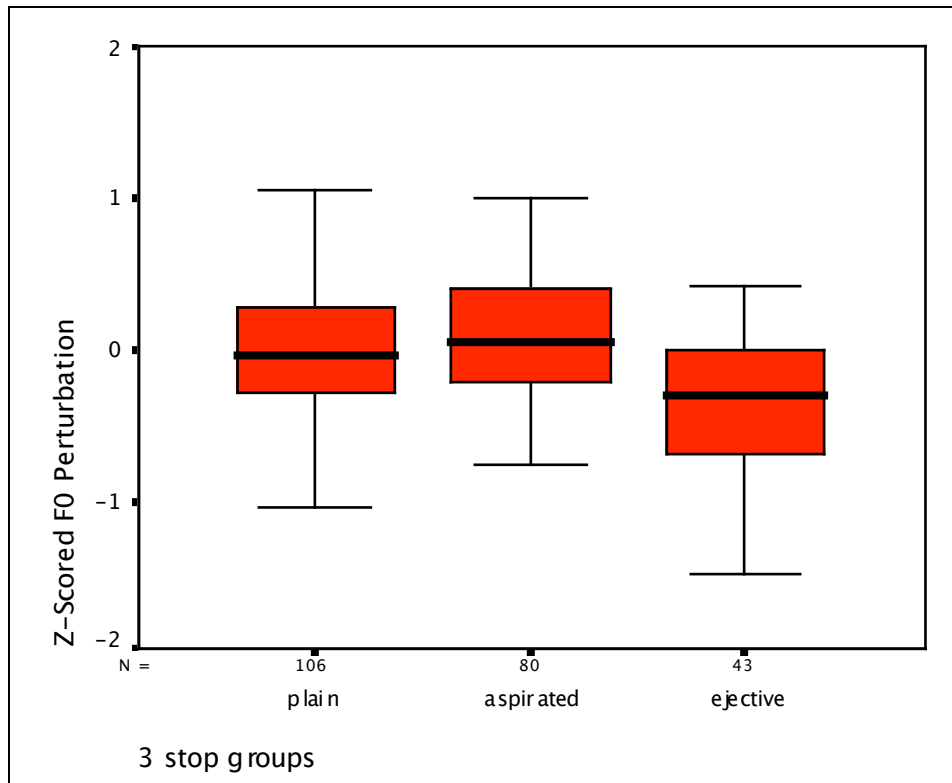
**Table 15. Results of Univariate Analysis of Variance and Post Hoc Tests: Mean F0 Perturbation**

		Mean Difference (I-II)	Standard Error	P-value ( $\alpha = 0.05$ )
Stop I	Stop II			
plain	aspirated	-0.52	3.66	0.98
plain	ejective	12.82	4.47	0.01*
aspirated	ejective	13.34	4.68	0.01*

**Table 16. Results of Univariate Analysis of Variance and Post Hoc Tests: Z-normalized F0 Perturbation**

		Mean Difference (I-II)	Standard Error	P-value ( $\alpha = 0.05$ )
Stop I	Stop II			
plain	aspirated	-0.02	0.14	0.98
plain	ejective	0.50	0.17	0.01*
aspirated	ejective	0.53	0.18	0.01*

**Chart 3. Z-normalized F0 Perturbation across 3 Stop Groups**



As seen in the chart, the z-scored F0 Perturbation measurements of the plain and the aspirated clustered together around the centre, while those of the ejective ranged broader from near 0 to close to -1. This F0 difference between ejective and non-ejective stops was also statistically significant, as shown in the table ( $p \leq 0.05$ ).

To sum up, similarly to the case of Jitter Perturbation, my data supported that a distinction could be made between Tsihqut'in ejective and non-ejective stops based on the pitch of the vowel after a stop.

Finally, the full values for Rise Time are summarized in Table 17 below.

**Table 17. Mean Rise Time across 3 Stop Groups<sup>35</sup>**

	Intensity: V onset (dB)	Intensity: V 30 ms (dB)	Intensity: V peak (dB)	Rise Time: V peak - 30 ms (dB)
Plain	71.6 (8.8)	75.8 (8.4)	77.2 (8.0)	<b>1.4 (1.5)</b>
Aspirated	66.8 (8.4)	72.8 (7.7)	74.2 (7.3)	<b>1.4 (1.2)</b>
Ejective	57.8 (9.6)	65.3 (7.6)	69.8 (6.3)	<b>4.5 (3.3)</b>

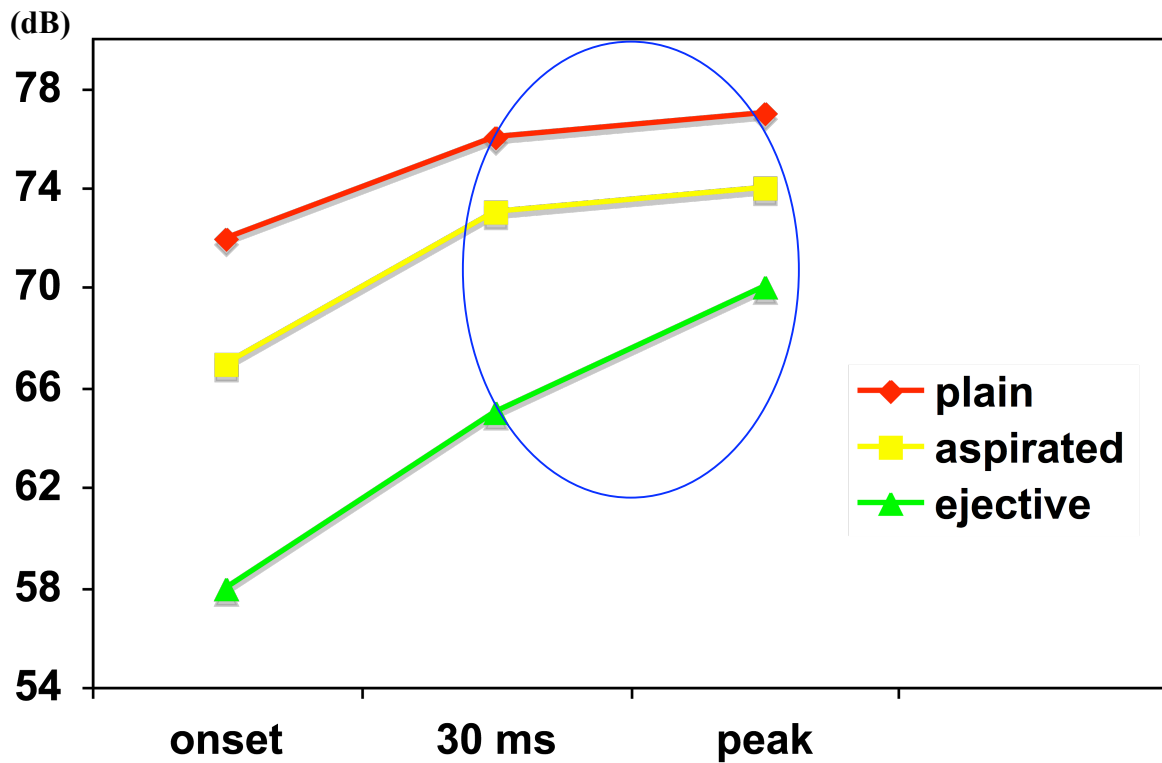
As illustrated above, the mean Rise Time results show that the ejectives had the slowest Rise Time (mean 4.5dB, SD 3.3dB), contrasting the much quicker Rise Time, 1.4dB, of the plain and aspirated stops<sup>36</sup>. The results, following the binary classification, indicate that the ejectives are *weak*.

In order to demonstrate this contrast visually, I prepared Chart 4 spotting the intensity values at the 3 points – the voicing onset, 30 ms, and the peak of the vowel after each stop.

<sup>35</sup> In the table, values in the parentheses are standard deviation (SD).

<sup>36</sup> I appreciate and agree with Dr. Yoon that the use of terminology is confusing here as I am talking about intensity but using the term “(rise) time.” However, as I base my methodology on Wright et al. (2002) and Hargus (2007), the further information on the Rise Time results in the rest of the section and on the measure in these earlier studies may help clarify the confusion.

Chart 4. Schematic Illustration of Mean Rise Time Values at 3 Points



The overall slope patterns in the chart show that the mean intensity of the plain and aspirated stops increase most from voicing onset to 30 ms into the vowel. By then, the intensity level is already near its peak and, thus, does not have much more to rise from there. On the other hand, the mean intensity of the ejectives continue to increase, or “rise,” from the voicing onset through 30 ms later and until its peak, thus yielding the slowest Rise Time among the three stop groups. These results coincide with what Wright et al. (2002) and Hargus (2007) found about 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. Therefore, this period, marked with a circle in the chart, distinguished the ejectives from the other stops in both Athabaskan languages.

The statistical results of the Rise Time in Table 18 and Table 19 below add evidence for such a distinction between the ejectives and the other stop classes.

**Table 18. Results of Univariate Analysis of Variance and Post Hoc Tests: Mean Rise Time**

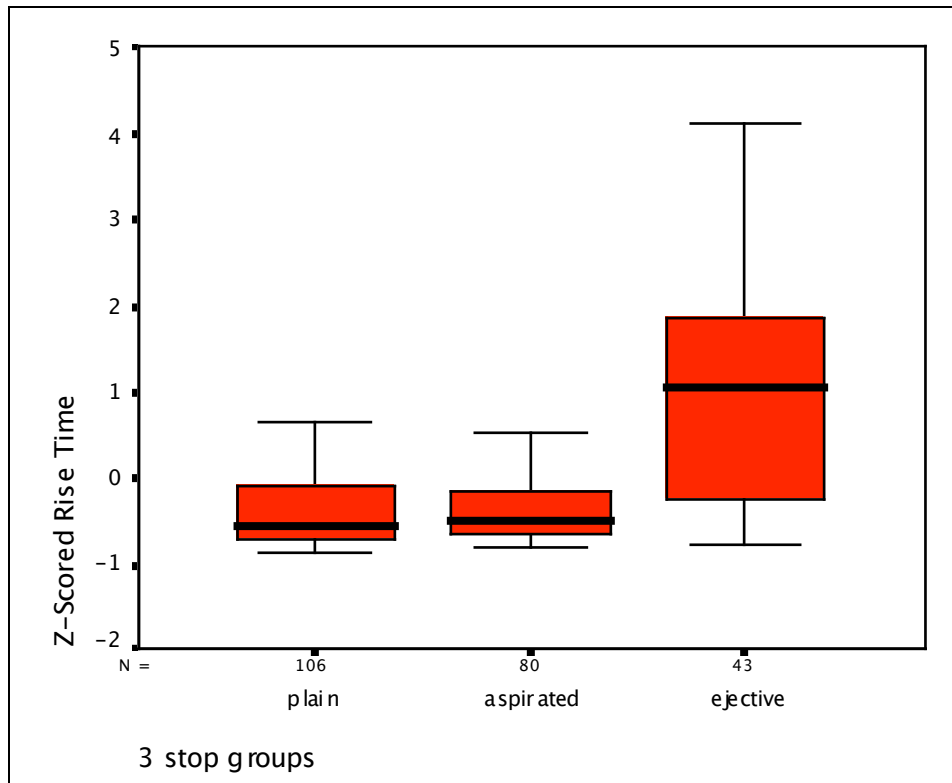
		Mean Difference (I-II)	Standard Error	P-value ( $\alpha = 0.05$ )
Stop I	Stop II			
plain	aspirated	-0.00	0.28	1.00
plain	ejective	-3.16	0.34	< 0.001*
aspirated	ejective	-3.15	0.36	< 0.001*

**Table 19. Results of Univariate Analysis of Variance and Post Hoc Tests: Z-normalized Rise Time**

		Mean Difference (I-II)	Standard Error	P-value ( $\alpha = 0.05$ )
Stop I	Stop II			
plain	aspirated	-0.00	0.12	1.00
plain	ejective	-1.39	0.15	< 0.001*
aspirated	ejective	-1.39	0.15	< 0.001*

By the measurements of the Rise Time, Tsilhqut'in stops can be grouped into two: the ejective group, and the plain and aspirated group. Both of the tables above prove this point as the comparison between the groups bears the significant result ( $p \leq 0.05$ ). This division between the ejective and non-ejective stops is also supported by Chart 5 below.

**Chart 5. Z-normalized Rise Time across 3 Stop Groups**



As seen in the boxplot, the z-normalized Rise Time values of the plain and aspirated stops clustered together between 0 and -1, whereas those of the ejective ranged much more broadly from 2 to -0.5.

In short, the distinction observed here between ejectives and the other stops means that according to the intensity findings from the data of the current study, ejective and non-ejective stops in Tsilhqat'in diverge into two separate groups.

To summarize this section of the intra-language comparison, compared to the plain and aspirated stops, the Tsilhqat'in ejectives had longer VOT (burst - voicing onset duration), higher Jitter (creaky quality) at the voicing onset, lower F0 (pitch) at the voicing onset, and slower Rise Time (intensity) between the 30 ms after voicing onset

and the peak of a following vowel<sup>37</sup>. Following the binary categorization of ejectives, then, the long VOT would be an indication that Tsilhqut'in ejectives are *strong*. On the other hand, the other three acoustic correlates: the higher initial creakiness, lower initial pitch, and the slower intensity rise would point to them being *weak*.

Now, it will be interesting to see how these findings from the present study compare with findings from other studies on ejective stops where different languages have been examined instrumentally. A description of such an inter-language comparison follows next.

#### 4.1.2 Inter-language Comparison

With all we have learned so far about Tsilhqut'in ejectives in terms of the four acoustic characteristics, we can make a further comparison between ejectives in Tsilhqut'in and ejectives in other languages. This inter-language comparison among seven different languages - Ingush, Hausa, Quiché, Tigrinya, Navajo, Witsuwit'en, and Tsilhqut'in – is summarized in Table 20 below.

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<sup>37</sup> One exception to this generalization is the VOT measure; the aspirated stops also showed the VOT values that were as long as those of the ejectives.

**Table 20. Comparison of Acoustic Characteristics of Ejectives across Languages (adapted from Warner 1006)**

	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)	aperiodic	aperiodic	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)
<b>Traditional Classification</b>	<b>?</b>	<b>weak</b>	<b>?</b>	<b>strong</b>	<b>strong</b>	<b>weak</b>	<b>?</b>

As shown 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. They do not exactly pattern as either of the types. That is, ejectives in these languages have a combination of *both* strong and weak properties at the phonetic level.

As discussed in the previous subsection 4.1.1, Tsilhqut'in ejectives show long VOT that is of the *strong* qualities. However, they also have creaky voice, lower pitch at

the voicing onset, and slower Rise Time to peak intensity, and these 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) causes even bigger difficulty classifying the sounds into either of the types since it falls somewhere between the two. Likewise, the VOT (50 ms) of Quiché ejectives is neither as long as that of Navajo 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).

To sum up, ejectives in the Tsilhqut'in language show a combination of *weak* and *strong* characteristics at the phonetic level, according to the results from the acoustic analysis of this study. In accordance with the findings from other ejective studies, this finding proves that the traditional ejective categorization does not sufficiently account for such, Athabaskan and non-Athabaskan, languages. Also, it supports for the claim that we need a better way to classify ejectives across languages of the world.

#### **4.2 Auditory Analysis: Auditory Impressions & Acoustic Characterization**

In addition to the acoustic investigation that we have discussed so far, I have carried out an impressionistic analysis. In this analysis, I examined my auditory impressions of the ejectives and compared what I perceived with the acoustic results. However, due to the very small number of the tokens (i.e. 43 ejectives), no absolute conclusion could be

drawn from the auditory results. Nonetheless, for further research whereby I hope to have more data, let me make notes on the methodology used and any slight trends observed in this perceptual examination.

Of the whole dataset, there were 43 ejective tokens (see APPENDIX I) that I listened to a number of times and categorized into one of three groups – *strong*, *weak*, or *uncertain*. Out of a total of 43, I perceived 33 as *strong*, 8 as *weak*, and the other 2 as *uncertain* (i.e. combination of both, *strong* and *weak*). My criteria for the categorization were purely impressionistic but based on auditorily-instructed perception. That is, when I heard a sound to be clearly an ejective, with forceful ejection, a strong burst, an audible friction, etc., I grouped the sound as *strong*. In the same manner, when a sound was without any obvious ejectiveness, audible burst or friction, or was similar to a Korean fortis stop<sup>38</sup>, then I categorized it as *weak*. Some ejectives were put into the third *uncertain* group since I heard them ambiguously and could not choose either strong or weak. As a result, I could not conclude from my perceptual judgments whether Tsilhqut’ in ejectives belong to a single group following the strong-weak dichotomy.

With all the ejectives put into three groups, I ran the same statistical analysis (i.e. Univariate Analysis of Variance and Post Hoc Tests) in order to see if what I perceived would bear any correlation with the phonetic characterization of the ejectives, which were determined from the acoustic examination earlier. Again, there do not seem to be any reliable grounds to base the statistical results on because the dataset was too small to

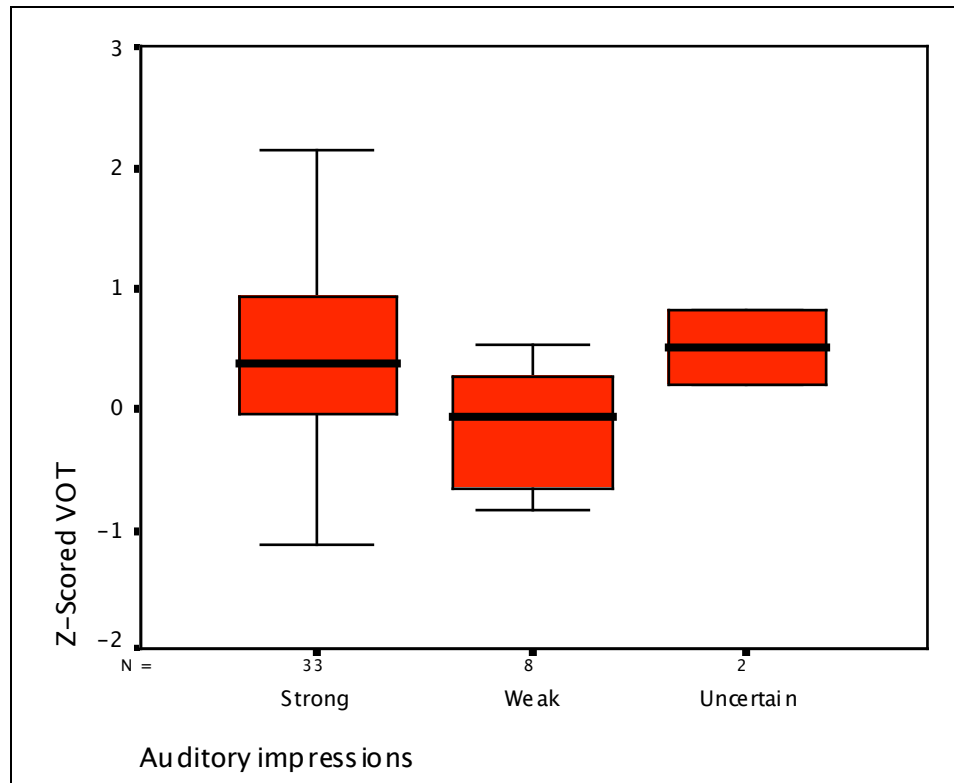
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<sup>38</sup> See *Handbook of the International Phonetic Association* for an illustration of the Korean sound system (pp. 120-123).

obtain anything meaningful. I have, nonetheless, decided to include in this section a brief part that looks at the results because it could be useful for my follow-up study.

Referring to the methodology, I intend to collect more data and conduct a further auditory examination, whereby proper statistical analyses can be run on results, and any observation made from this experimental analysis may be considered or even validated.

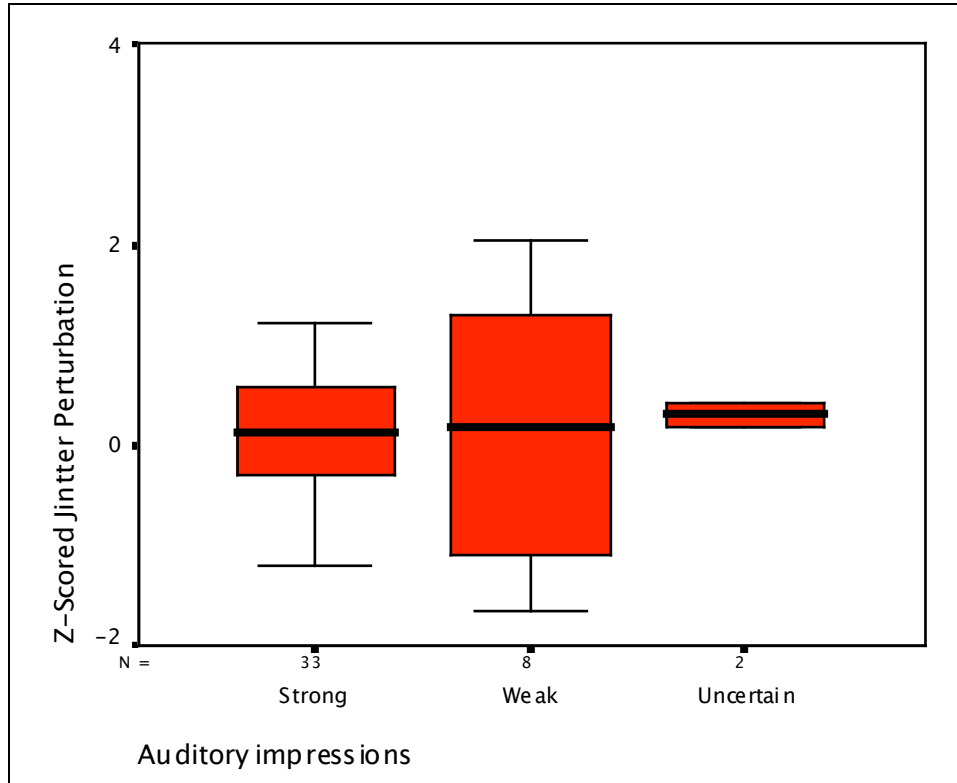
When I compared my auditory judgments of the ejectives with their acoustic measurements, there seemed to be one interesting tendency in relation to a distinction between 33 “strong” ejectives and 8 “weak” ejectives. In other words, as in Chart 6 below, the strong ejective group seemed to be composed of the ejectives with relatively long VOT, whereas the weak group was made of the ones that had shorter VOT values.

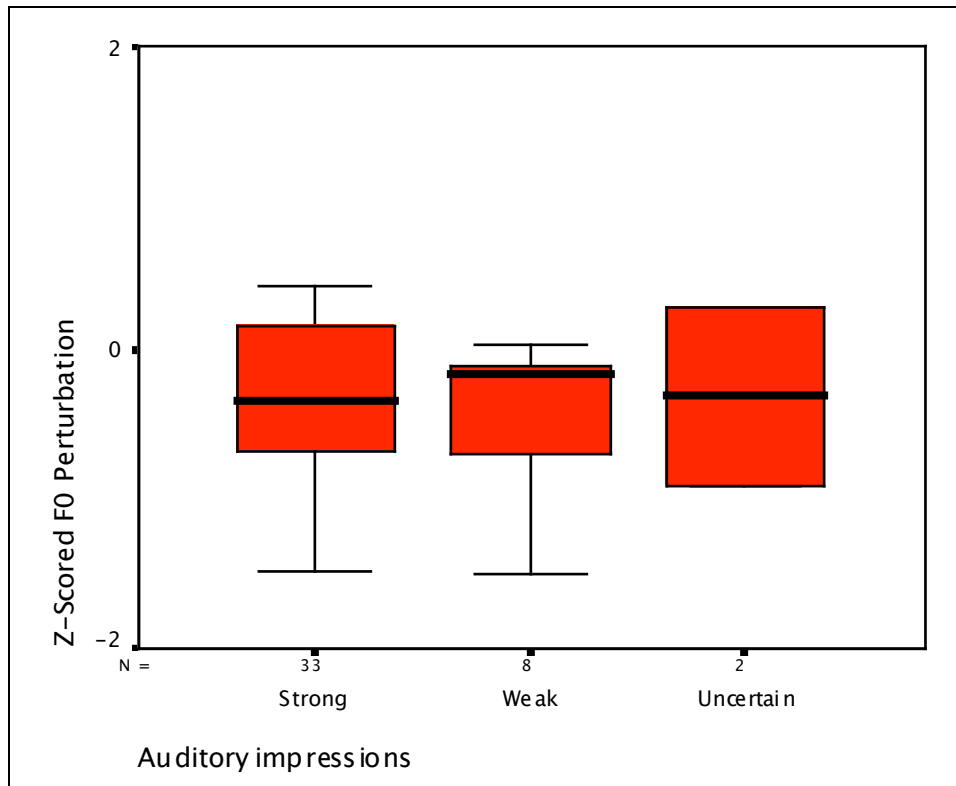
**Chart 6. Comparison: Auditory Impressions and VOT**

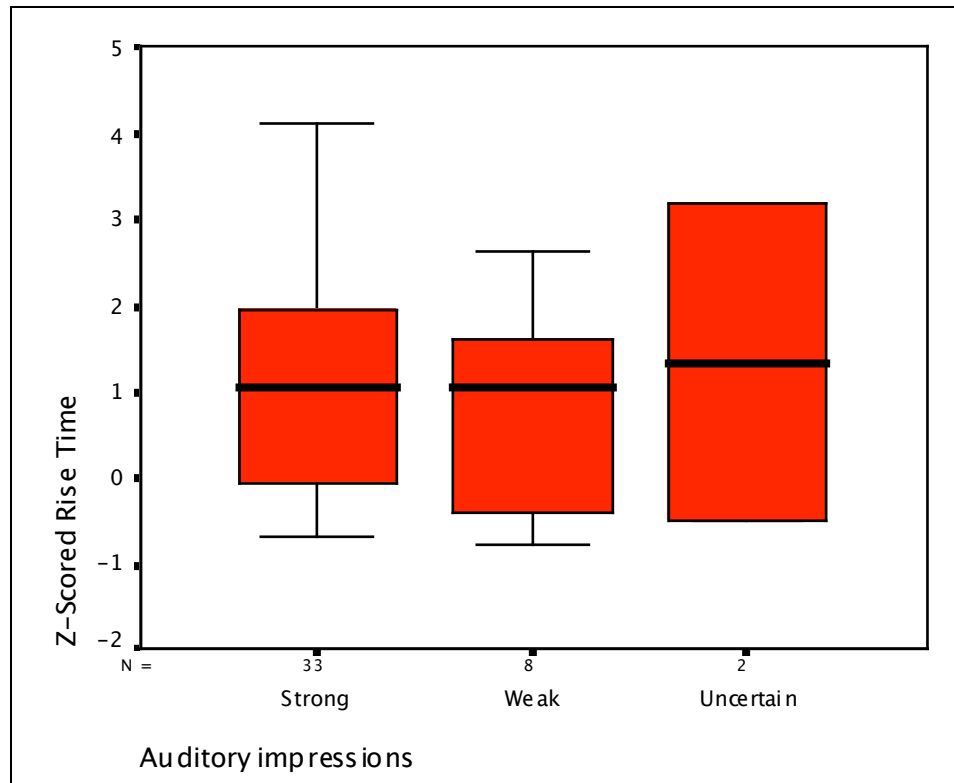
In the chart above, the box of the strong ejectives is positioned higher than that of the weak. The VOT values of the former range towards a bigger or positive figure, such as 1, while those of the latter spread towards a smaller or negative figure like -1 on the axis.

In the case of the other measures (i.e. Jitter Perturbation, F0 Perturbation, and Rise Time), on the other hand, there did not seem to be any clear pattern or tendency. No generalization could be made from what is shown through Chart 7, Chart 8, and Chart 9 below.

**Chart 7. Comparison: Auditory Impressions and Jitter Perturbation**



**Chart 8. Comparison: Auditory Impressions and F0 Perturbation**

**Chart 9. Comparison: Auditory Impressions and Rise Time**

In short, as mentioned earlier, due to the small number of tokens used in these analyses, none of the findings here are conclusive. The auditory analysis was only a trial and the subjective observation that the strong ejectives may be associated with longer VOT calls for confirmation by further research.

More elaborated discussions of all the findings from these acoustic and auditory investigations follow in next chapter.

## Chapter Five

### DISCUSSION

In this chapter, I will elaborate on the results and findings from the current phonetic study of Tsilhqutʼin ejectives. In other words, as outlined in the previous chapter, we will discuss the results in more detail from the acoustic analysis (Section 5.1) – first, about the intra-language comparison and then, about the inter-language comparison. Our further discussion will then carry on to the findings from the auditory analysis (Section 5.2). In doing so, some findings from other ejective studies will be brought up and looked at closely in comparison with those from the current instrumental investigation. This will shed light on our inquiry about the typology of ejectives across languages.

#### 5.1 Acoustic Analysis

To recall the traditional dichotomy of ejectives established through earlier work, such as Lindau 1984 and Kingston 1985, let me recap typical phonetic properties of strong, or stiff, and of weak, or slack, ejectives<sup>39</sup>. I will also briefly talk about the four acoustic correlates chosen for the study of Tsilhqutʼin ejectives.

According to the literature, strong ejectives usually have long VOT, modal or tense voice, raised pitch and a sudden intensity (or amplitude) increase at the onset of voicing, and are easy to perceive. On the other hand, weak ejectives typically show short

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<sup>39</sup> These terms suggest a strong or stiff vs. weak or slack setting of the vocal folds, and as to shift the paradigm, I would like to think of the difference as implying *more* vs. *less* of a degree of laryngeal constriction being present (my thanks to Dr. Esling for the clarification).

VOT, creaky voice, lowered pitch and a gradual intensity increase at the onset of voicing, and are hard to perceive. Accordingly, four of these correlates were selected to be measures of the current phonetic study in order to determine whether the Tsilhqut'in ejectives belong to either type of strong or weak ejectives or they pattern differently from this binary categorization. Table 3 below is taken from Chapter 2 to illustrate the chosen acoustic correlates with two types of ejective stops.

**Table 3. Four Acoustic Measures**

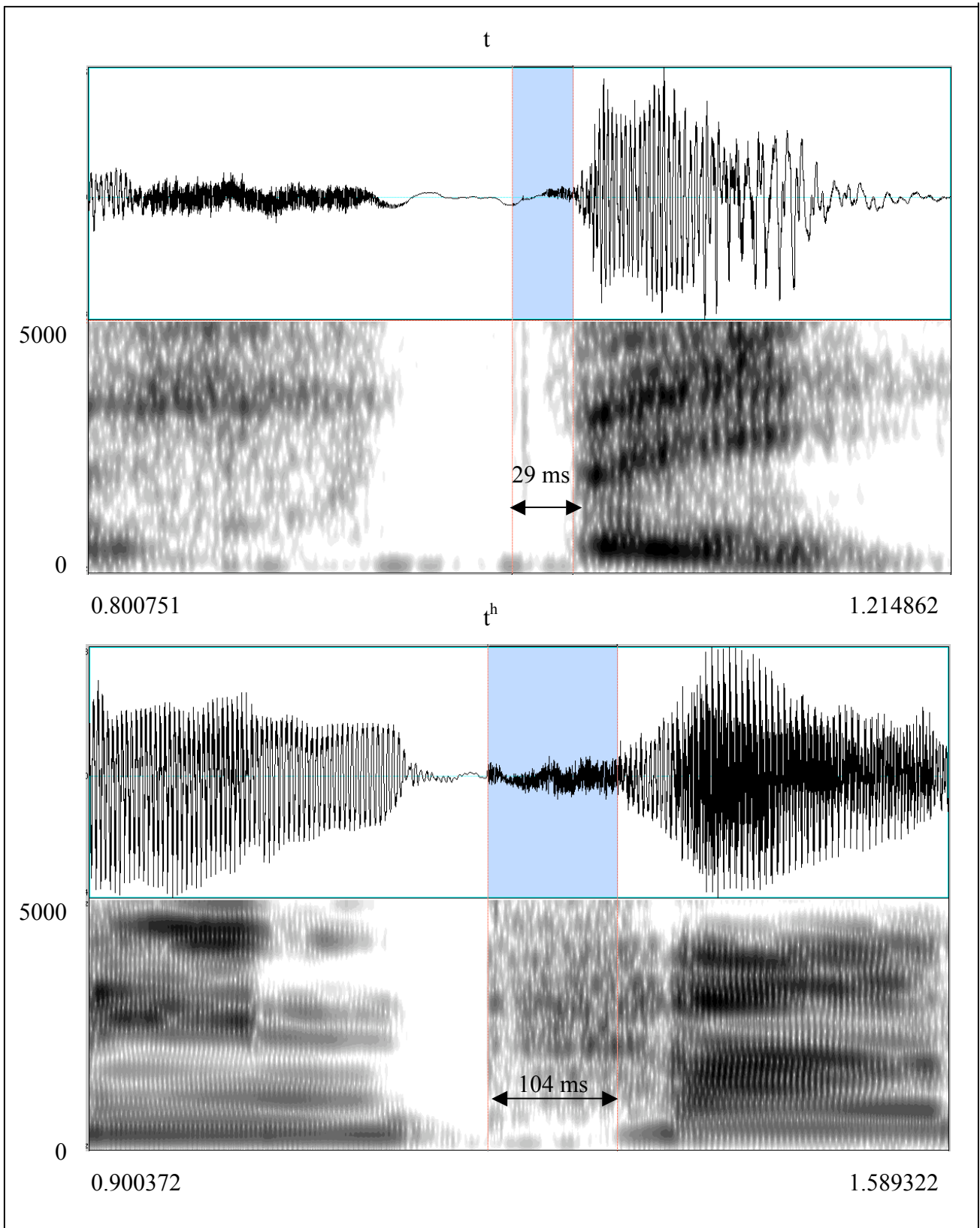
Correlates	Strong	Weak
VOT ( <i>VOT</i> )	long	short
Voice quality ( <i>Jitter Perturbation</i> )	modal or tense	creaky
Pitch at voicing onset ( <i>F0 Perturbation</i> )	raised	lowered
Amplitude at voicing onset ( <i>Rise Time</i> )	sudden increase	gradual increase

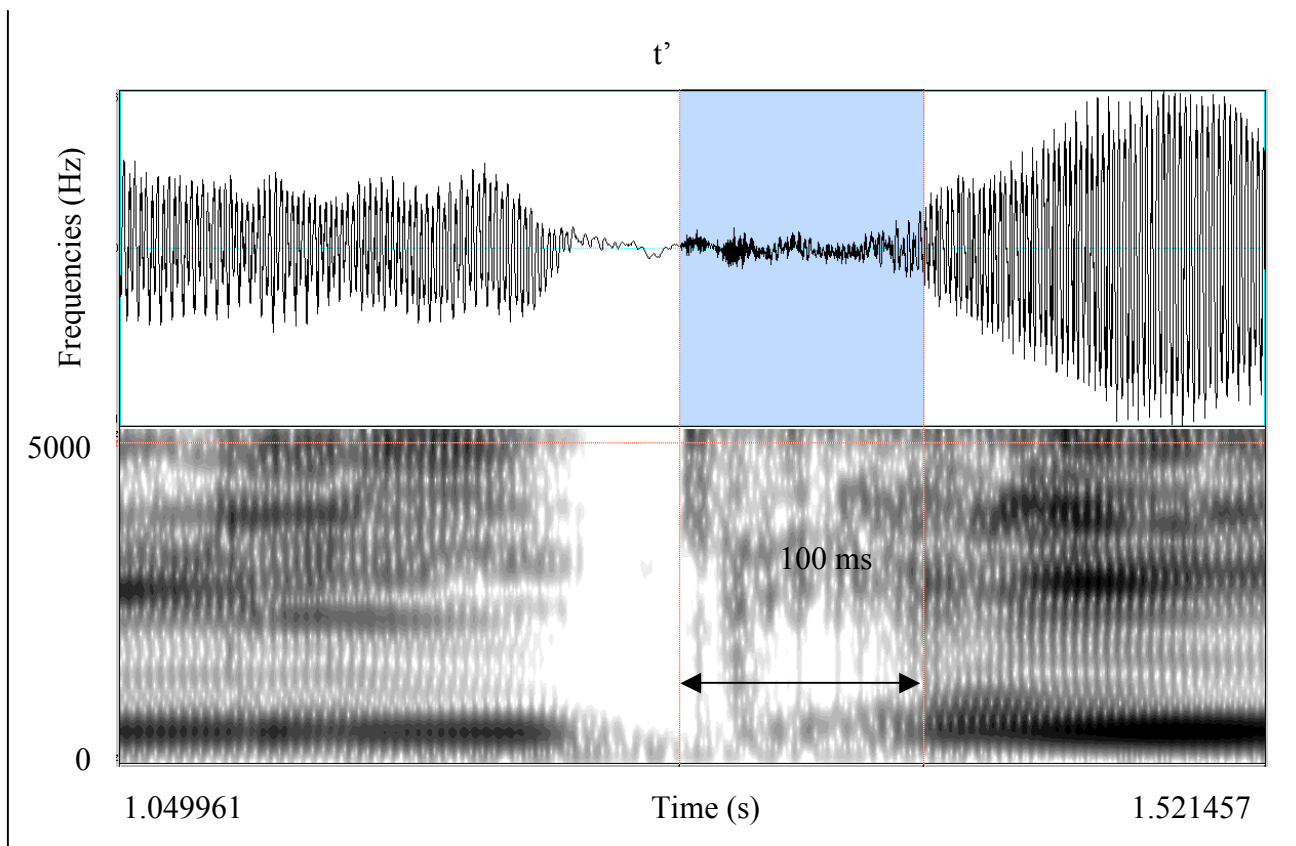
### 5.1.1 Intra-language Comparison

Let us have a closer look at what was found of Tsilhqut'in ejectives from the acoustic examination.

First, in terms of VOT, the data used in this study reveal a statistically significant contrast between the plain stops and the aspirated and ejective stops. In other words, VOT is found to be an acoustic cue that distinguishes the plain from the other two groups of the stops in the language. The following spectrograms and waveforms in Figure 11 are

provided to show such a contrast between the two groups: plain stops and aspirated and ejective stops.





**Figure 11. Waveforms and Spectrograms Demonstrating the Plain Stop  $d$  [t], Aspirated Stop  $t$  [tʰ], and Ejective Stop  $t'$  [tʰ̣] in the Words *sidišdinh* “s/he felt my presence,” *nendanintan lha bededilghez* “the door is not locked,” and *nendenedi(n)lhtʰi* “s/he closed the entrance (door, gate, etc.)” Respectively**

This finding that the ejectives showed long VOT, as the aspirated stops do, entails a conclusion that based on the binary classification, Tsilhqutʼin ejectives are strong.

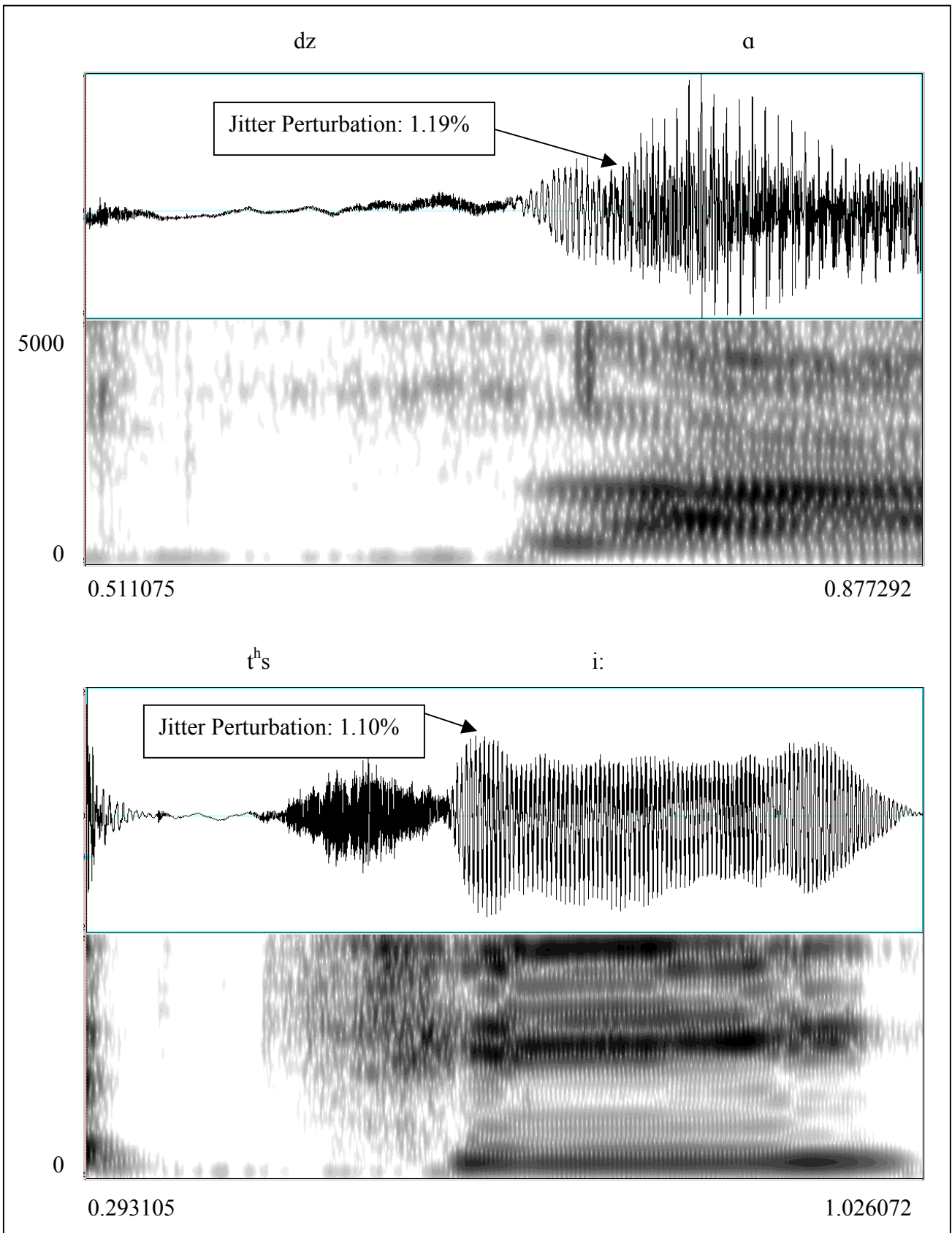
The finding that they have the *long-VOT* pattern similar to that of the aspirated is in agreement with what past ejective studies discovered about ejectives in other languages. For instance, McDonough (2003) found that ejectives in Navajo, an

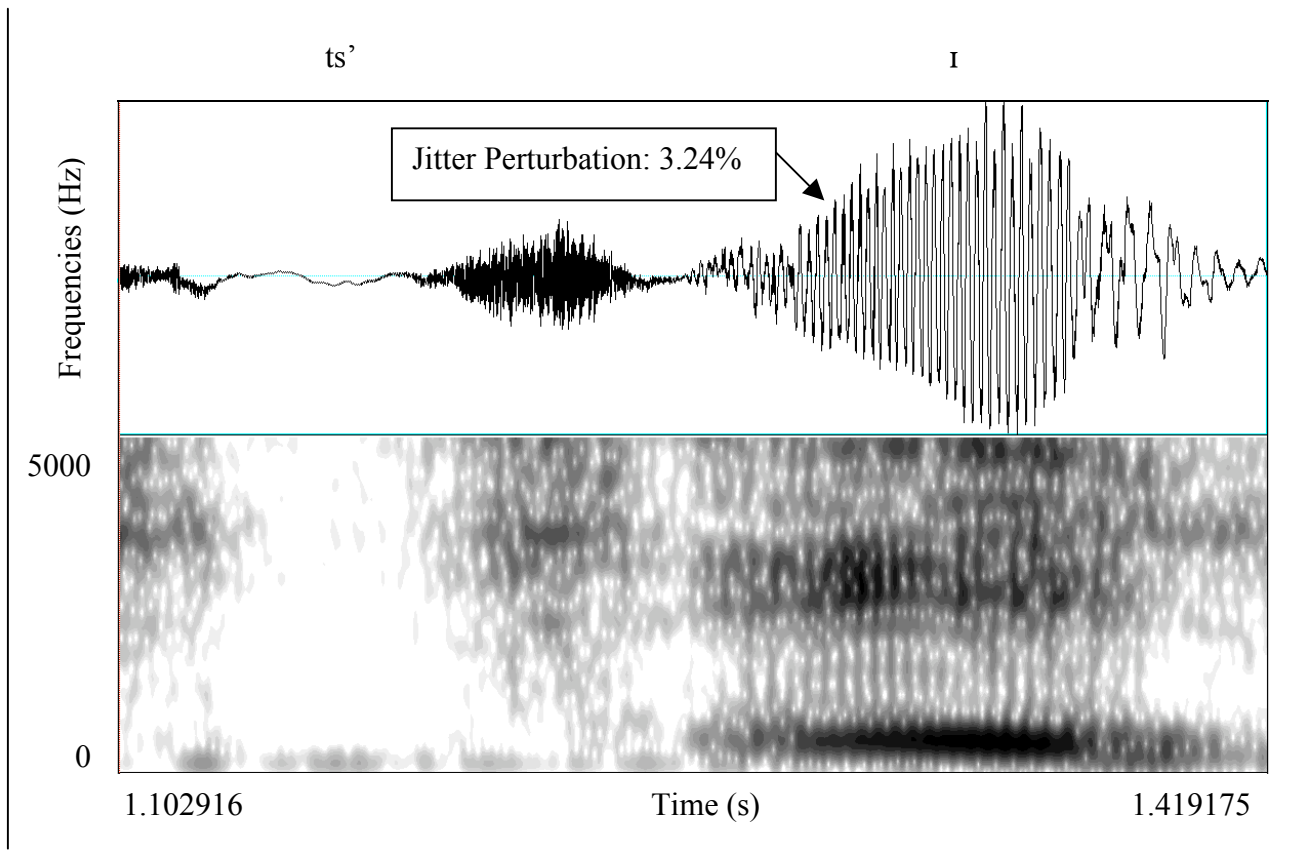
Athabaskan language, had VOT (94 ms – 157 ms) that was similar to the long VOT of the aspirated (130 ms – 154 ms), but was much longer than that of the plain, or unaspirated (6 ms – 91 ms) (p. 91). Based on VOT, Navajo stops, like Tsilhqut'in stops, could be divided into two groups: the plain stops and the aspirated and ejective stops.

Second, regarding the Jitter Perturbation, or the quality of voicing, of the post-stop vowels, the data of the current study show that a two-way distinction could be made between the ejectives and the other stops in the Tsilhqut'in language. The Jitter results showed that ejectives had creakiness in their voicing quality (of the following vowel) and that the ejective and non-ejective stops therefore diverge into two separate groups. This means that the Jitter measure or creakiness can be used as an acoustic cue to distinguish ejectives from the plain and aspirated stops in Tsilhqut'in<sup>40</sup>. Figure 12 in the following is provided to show such a contrast between the ejective and non-ejective stops.

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<sup>40</sup> I am thankful to Dr. Esling for his comment on this finding that the force of closure might be less during articulation of Tsilhqut'in ejectives than it is during that of Korean fortis stops, despite the long period of (positive, or +) VOT and closure.





**Figure 12. Waveforms and Spectrograms Demonstrating the Plain Stop *dz* [dz], Aspirated Stop *ts* [t<sup>h</sup>s], and Ejective Stop *ts'* [ts'] in the Words *ʔelhdzagh* “s/he is playing a string game,” *ʔetsi* “grandfather,” and *belhadelhts'ish* “s/he/it is yawning,” Respectively**

According to the traditional dichotomy, based on Jitter Perturbation, Tsilhqut'in ejectives would be considered as weak. The creaky voicing quality in following vowels is one of the phonetic properties of weak ejectives as found by the early work on ejectives (e.g. Lindau 1984 and Kingston 1985).

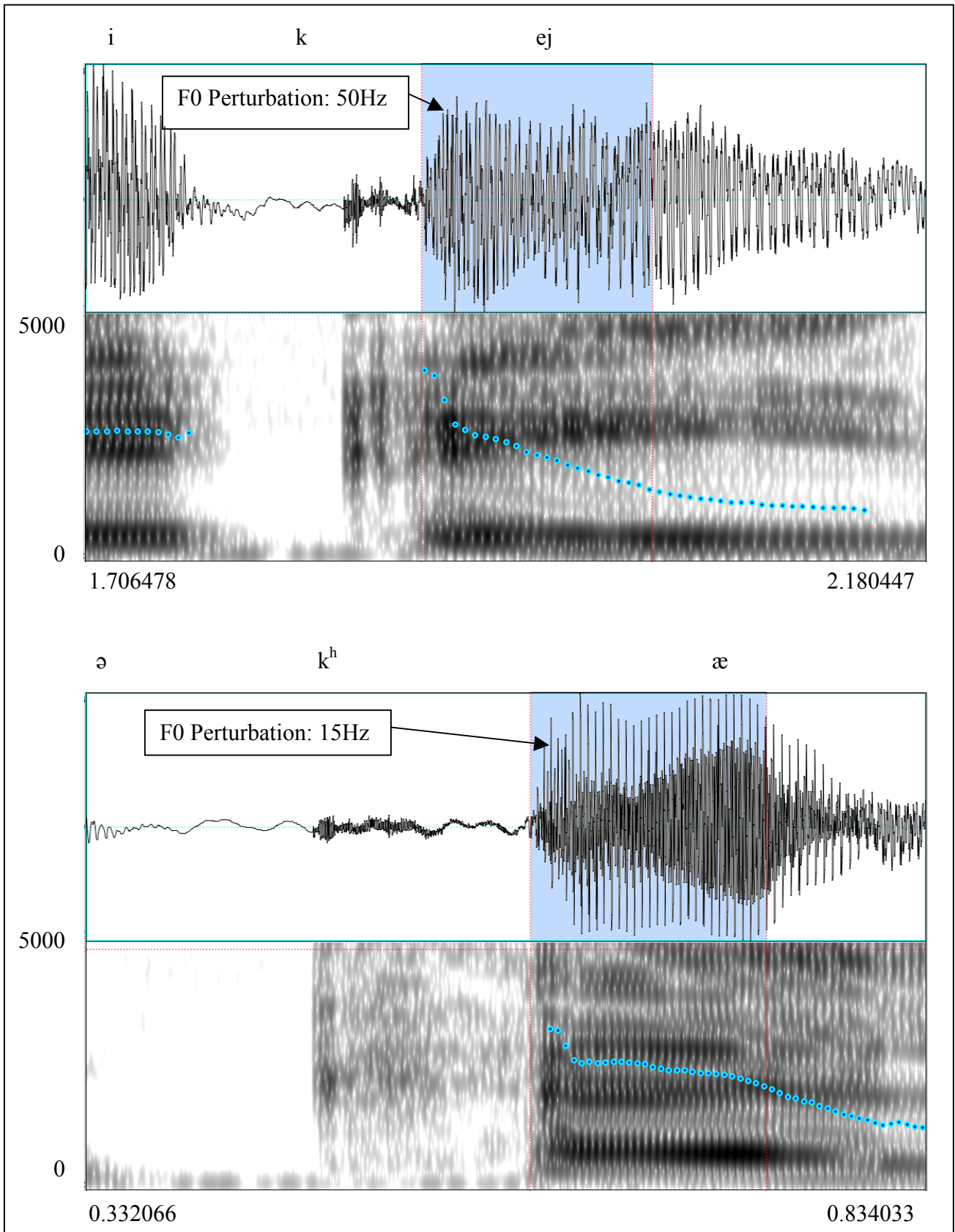
Wright et al. (2002), through a more recent instrumental study of Witsuwit'en alveolar ejectives, found that the ejectives had mean Jitter of 6.9 %, while the other stops had much smaller Jitter around below 2 % (p. 51). This creaky phonation differentiated

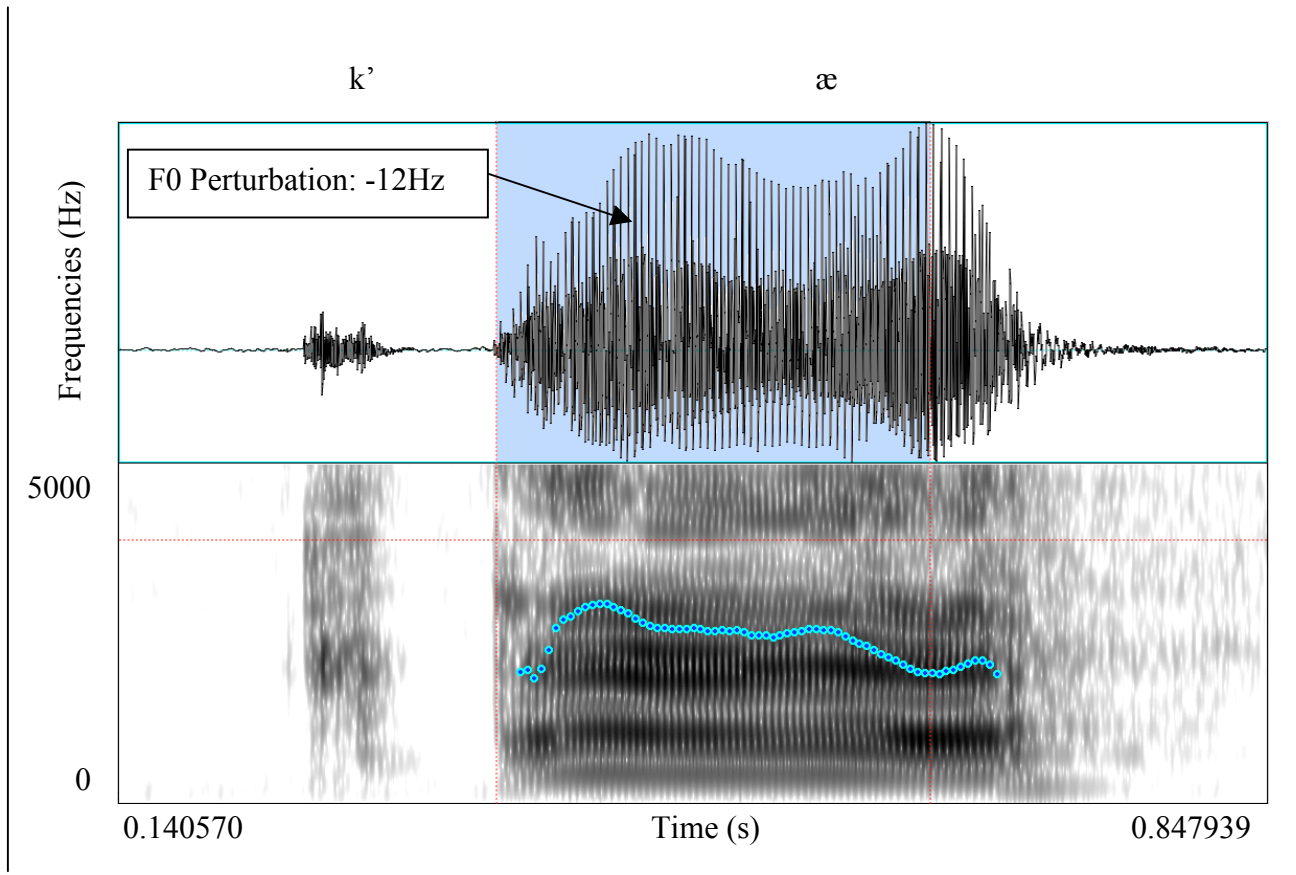
the ejectives from the other corresponding plain (or voiceless unaspirated) and aspirated stops in this Athabaskan language.

Third, the increase in pitch of a vowel after an ejective is another indication that the Tsilhqut'in ejectives may be weak. As similar to the case of Jitter Perturbation, my data support a distinction that could be made between Tsilhqut'in ejective and non-ejective stops by the pitch of the vowel following the stop. Recall that the ejectives have the lowest pitch at voicing onset (mean 209Hz, SD 45Hz) and then the biggest increase into the midpoint of the post-stop vowel (mean -5Hz, SD 38Hz). In contrast, the vowels after the non-ejective stops drop their pitch from the voicing onset to the midpoint. Figure 13 below shows the spectrograms that are provided to demonstrate such a distinction between the ejectives and plain and aspirated stops<sup>41</sup>.

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<sup>41</sup> The line in each spectrogram shows the pitch range.





**Figure 13. Waveforms and Spectrograms Demonstrating the Plain Stop  $g$  [k], Aspirated Stop  $k$  [k<sup>h</sup>], and Ejective Stop  $k'$  [kʰ] in the Words *yixigiz* “it bit it/him/her,” *dekal* “it is round (flat object or fabric),” and  $k'a$  “arrow,” Respectively**

Based on the binary typology, initially low pitch at the voicing onset, which later increases through the vowel midpoint, is an acoustic cue for Tsilhqut'in ejectives to be weak.

In Kingston's phonetic study (1985), Quiché ejectives were compared to Tigrinya ejectives. Adding evidence to the traditional categorization, Kingston classified the former as weak and the latter as strong according to the results of some acoustic measures. The F0, or pitch, measurement was one such measure and was found to be discriminative between the two ejective groups. That is, Quiché ejectives, at the onset of

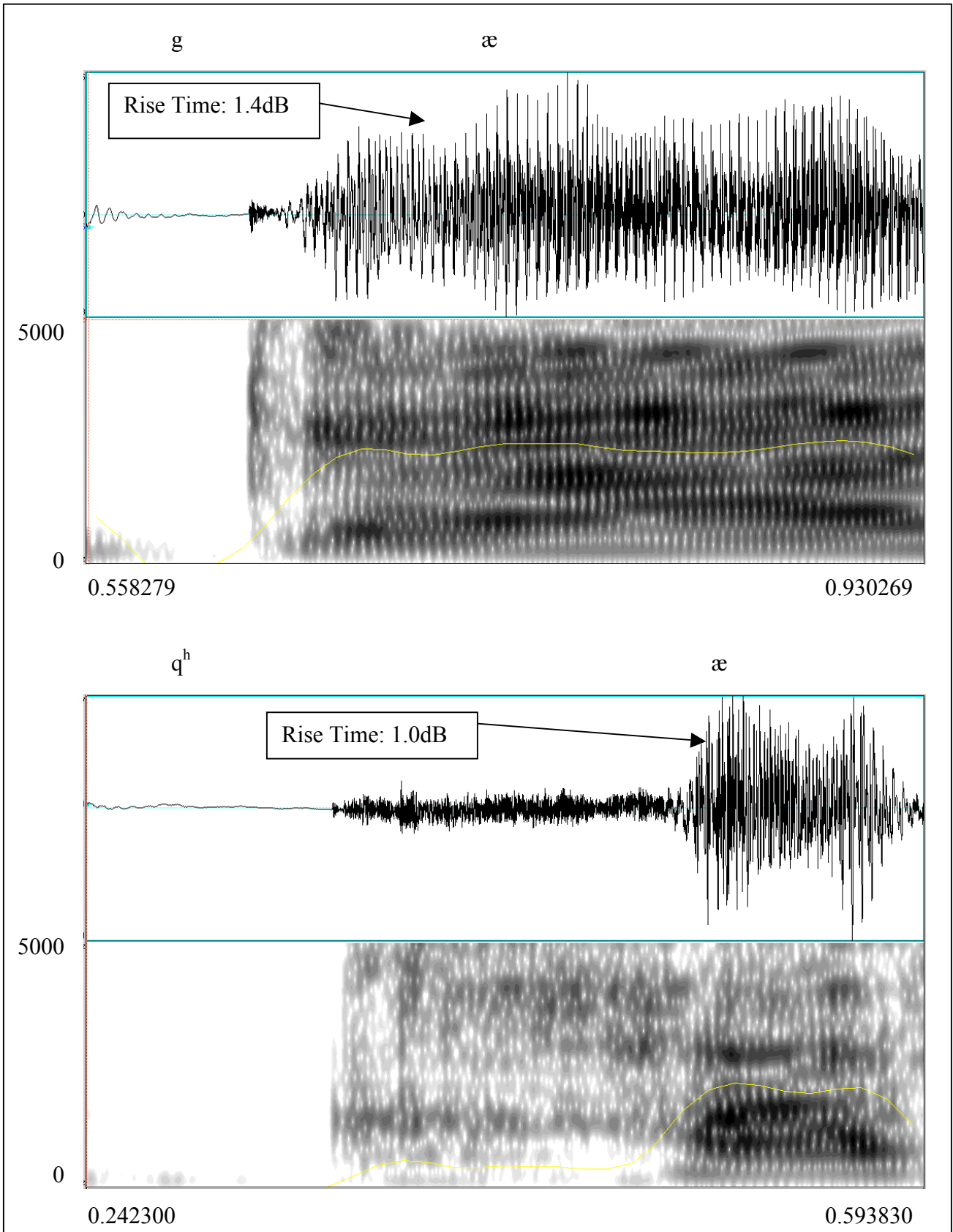
the voicing, revealed pitch values that were much lower than those of Tigrinya ejectives at the voicing onset.

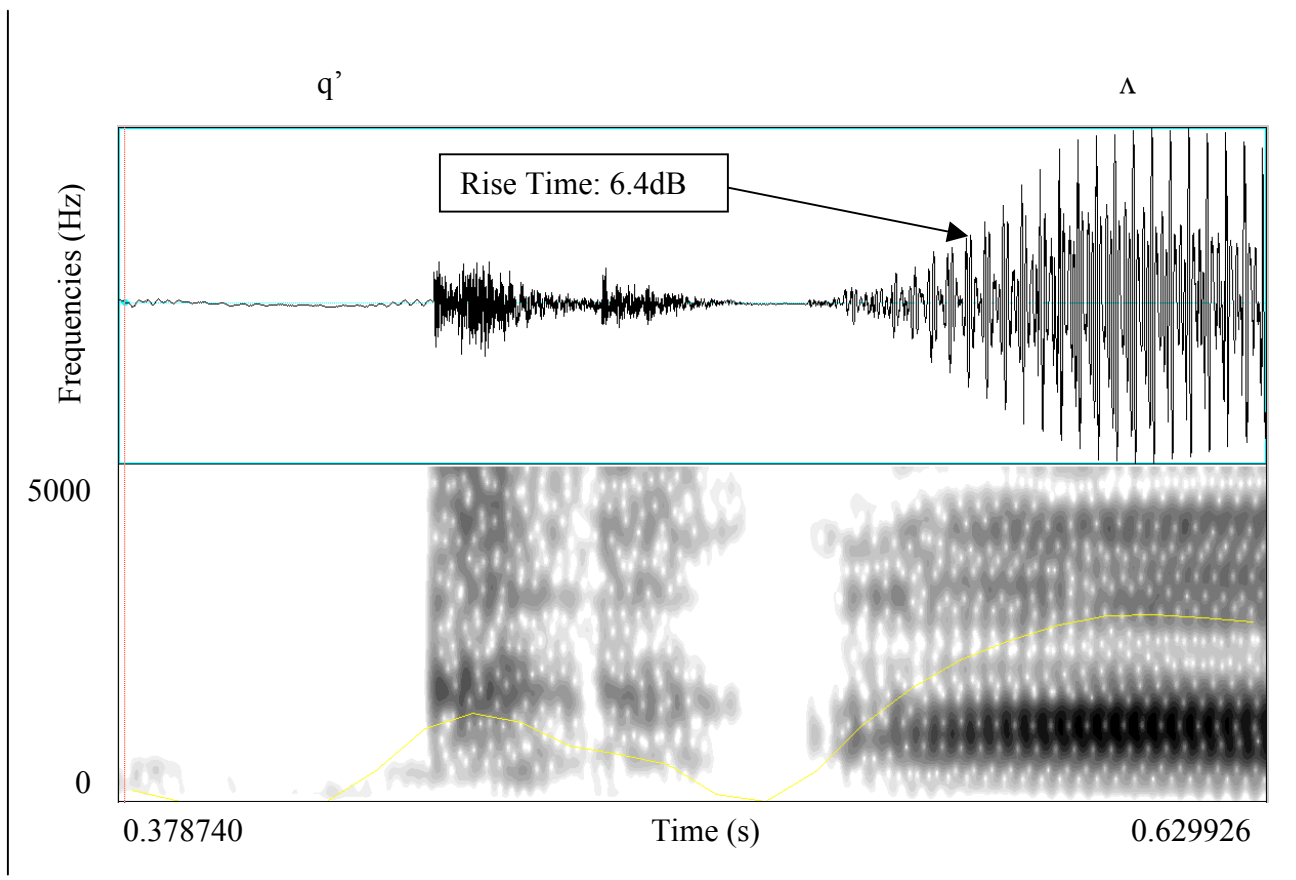
In addition, it is interesting to see that the results of the Jitter and F0 Perturbation in the present study are correlated here. That is, creaky voice and pitch go together, as creaky voice has low F0. The figures of the two measures from this study show that the Tsilhqut'in ejectives have the highest Jitter Perturbation values and the lowest F0 measurements. This means that they, in their voicing quality, had more creakiness and lower pitch at the voicing onset, compared to the other plain and aspirated stops.

Lastly, the mean Rise Time results revealed that the ejectives have the slowest Rise Time (mean 4.5dB, SD 3.3dB), contrasting the much faster Rise Time, 1.4dB, of the plain and aspirated stops (SD 1.5dB and SD 1.2dB, respectively). This contrast between the two groups – ejective stops and plain and aspirated stops – is illustrated by the following spectrograms and waveforms in Figure 14<sup>42</sup>.

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<sup>42</sup> The thin solid line in each spectrogram shows the amplitude range.





**Figure 14. Waveforms and Spectrograms Demonstrating the Plain Stop  $g$  [g], Aspirated Stop  $q$  [q<sup>h</sup>], and Ejective Stop  $q'$  [qʰ] in the Words *nengan* “your (sg.) hand,” *?eqelh* “leather,” and *gwezq'ez* “it is cold; cold weather,” Respectively**

Following the strong-weak classification, this finding also suggests to us that the Tsilhqut' in language has weak ejectives. In other words, gradual increase of amplitude, or slow rise time, of a vowel after a stop is an acoustic characteristic found to be correlated with weak ejectives.

The slow rise-to-peak intensity is also observed with other languages such as Ingush. Warner's phonetic study of Ingush ejectives (1996) showed that the rise to peak amplitude of a vowel following an ejective was also slower than that of a vowel following the other, pulmonic voiceless, stop in the language.

To sum up, through this intra-language comparison, we have seen the results of the four acoustic correlates that clearly differentiate the ejectives from the other stops in Tsilhqut'in. In contrast to the plain and aspirated stops, the Tsilhqut'in ejectives had longer VOT (burst - voicing onset duration), higher jitter (creaky quality) at the voicing onset, lower F0 (pitch) at the voicing onset, and slower Rise Time (intensity) between the 30 ms after voicing onset and the peak of a following vowel. Adapted from Table 3 shown earlier, these results are summarized in Table 21 below, with the findings of the Tsilhqut'in ejectives.

**Table 21. Tsilhqut'in Ejectives - Results of Four Acoustic Measures**

Correlates	Strong	Weak
VOT ( <i>VOT</i> )	long	short
Voice quality ( <i>Jitter Perturbation</i> )	modal or tense	creaky
Pitch at voicing onset ( <i>F0 Perturbation</i> )	raised	lowered
Amplitude at voicing onset ( <i>Rise Time</i> )	sudden increase	gradual increase

As illustrated above, according to the binary categorization of ejectives, then, the long VOT would be an indication that Tsilhqut'in ejectives are *strong*. On the other hand, the other three acoustic properties of the ejectives, the higher initial creakiness, the lower initial pitch, and the slower intensity rise, would indicate that the ejectives would belong to the *weak* category. Overall, Tsilhqut'in ejectives do not completely fit into either of the

types. They instead show a mixture of both strong and weak characteristics at the phonetic level<sup>43</sup>. Accordingly, the traditional ejective dichotomy could not apply to classifying these ejectives in Tsilhqut'in.

With this issue in mind, we will move onto the second, inter-language, comparison. In the previous chapter, we have talked about overall results of comparing all the findings from the present study with findings from other ejective studies where different languages have been examined instrumentally. Now, let us have a closer look at them and see what conclusions, if any, could be drawn.

#### 5.1.2 Inter-language Comparison

In terms of the four acoustic correlates, Tsilhqut'in ejectives are compared with six other languages - Ingush, Hausa, Quiché, Tigrinya, Navajo, and Witsuwit'en. Table 22 below is taken from Table 20 in Chapter 4.

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<sup>43</sup> As Dr. Yoon points out, it is possibly that I have too few tokens to see the emerging categories.

**Table 22. Comparison of Acoustic Characteristics of Ejectives across Languages**

	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)	aperiodic	aperiodic	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)
<b>Traditional Classification</b>	<b>?</b>	<b>weak</b>	<b>?</b>	<b>strong</b>	<b>strong</b>	<b>weak</b>	<b>?</b>

If we were to classify these ejectives into either *strong* or *weak*, we would run into a problem with three of the languages. Ejectives in Ingush and Quiché do not exactly pattern as either of the types. As we have seen and discussed in the previous chapters, this is also the case with Tsilhqut'in ejectives. Let us have another look at what has been found about Ingush ejectives. Ingush ejectives had mean VOT of 50 ms. This is somewhat puzzling because it could not be a clear phonetic trait of either strong or weak. In the case of Navajo, which is viewed as one of the typical strong ejectives, mean VOT

is around 80 ms, as shown in the sixth column. On the other hand, Hausa, which is, as an example of weak ejectives, frequently compared to strong ejectives, yield much shorter mean VOT of 25 ms as shown in the third column. The result of this duration measure, somewhere between strong and weak, does not indicate whether Ingush ejectives should be categorized into one or the other group. Another problem in determining the categorization of the ejectives in this language is the conflicting results of the F0 and Rise Time measurements. While the initial high pitch at the voicing onset is one of the acoustic properties of strong ejectives, the slow rise to its peak intensity of a vowel after a stop is that for weak ejectives. These contrastive results are problematic in classifying Ingush ejectives as belonging to either of the types.

A similar problem occurs with ejectives in Quiché. Although the rest of the acoustic measures seem to be correlated with the traits of the weak ejectives, their mean VOT of 50 ms is not a clear-cut cue for distinguishing the sounds from the strong ejectives. The resulting VOT of Quiché ejectives is too short to be among the strong traits and too long to be among the weak characteristics. As the last row shows (i.e. “Traditional Classification”), ejectives in such languages as Hausa, Tigrinya, Navajo, and Witsuwit'en may be categorized into either strong or weak. However, the other languages, Ingush, Quiché, and Tsilhqat'in, cannot be accounted for by this binary classification since their phonetic qualities consist of both types of ejectives, as we have seen so far.

Moreover, even among those clearly categorized languages, some other issues occur, such as speaker variation. As discussed in the previous chapters (e.g. Chapter 2),

Bird (2002a) noticed significant speaker variation while studying Lheidli, a dialect of Dakelh (Carrier), a Northern Athabaskan language. In the production of ejective stops, a single speaker of Lheidli varied between the two types of strong and weak ejectives. Bird's auditory impressions with quantified differences in VOT seemed to be in accordance with the speaker variability observed in another Northern Athabaskan language. Wright et al. (2002) and Hargus (2007) in the phonetic studies of Witsuwit'en also reported a wide range of inter-speaker variation revealed in the production of the ejectives. They claimed that as none of the speakers showed an exact pattern or type of either strong or weak, the notion of *average* ejective was "problematic" (p. 69). The authors therefore argued that the dichotomous typology of ejectives was "inadequate" (p. 70). The findings from both within-language and across-language comparisons of the current phonetic study are in agreement with this view, too.

To sum up, according to the results from the acoustic analysis, ejectives in the Tsilhqut'in language have a combination of *weak* and *strong* characteristics at the phonetic level. In accordance with the findings from other ejective studies, such as Ingush and Witsuwit'en, this finding indicates that the traditional binary categorization does not sufficiently account for either Athabaskan or non-Athabaskan languages. It supports the claim that we need a better way of classifying ejectives across languages in the world.

In the last section of this chapter, I will discuss further the results from the auditory analysis of the ejectives in Tsilhqut'in.

## 5.2 Auditory Analysis: Auditory Impressions & Acoustic Characterization

In this auditory analysis, I examined how I perceived 43 ejective tokens and how my perception would compare with the phonetic characterization of the ejectives drawn from the earlier acoustic analysis. The results show that my auditory impressions of the sounds are more towards strong than weak. Table 23 below illustrates this auditory tendency.

**Table 23. Auditory Impressions of Tsilhqut'in Ejectives**

Ejectives	Strong	Weak	Uncertain
Total (43)	33	8	2

Out of 43 ejectives, I perceived and categorized 33 ejectives as strong, 8 as weak, and the other two as uncertain (i.e. unsure as they sounded like both strong and weak). Again, due to such a small number of tokens, however, no firm conclusion could be drawn from this result. Nonetheless, for further research to follow up, let me make sure if there are any interesting tendencies that could be noticed in this impressionistic examination.

As seen in the table above, the auditory examination shows mixed results, as the acoustic analysis does. That is, in terms of frequency, although over 75% (i.e. 33 out of 43) of my auditory impressions were of strong ejectives, the other 10 ejectives are perceived as weak or of both types, composing the other 23% of my perception of the sounds.

Now, recall those boxplot charts from our discussion on the results of the current study. In Chapter 4, they were presented to illustrate a possible correlation, if any,

between the auditory results and the acoustic results (from the four measures). Of those boxplots of VOT, Jitter Perturbation, and of Rise Time, the mean VOT of the strong ejectives appears to be higher than that of the weak. As mentioned earlier, no firm conclusion can be drawn from the comparison between the results from the auditory analysis and the acoustic analysis due to the insufficient number of the tokens.

Overall, neither the auditory impressions nor the acoustic examination of Tsilhqut'in ejectives show results that convince us to reach a conclusion that they are clearly strong or weak. Based on the acoustic analysis and my auditory judgments, what has been found and discussed of Tsilhqut'in ejectives so far seems to point us to the direction that the traditional ejective typology should be reconsidered.

Again, due to the small data used in the present study, none of the findings here could be interpreted as absolutely conclusive. They should be regarded as suggestive and used as foundations based on which further research needs to follow.

## **Chapter Six**

### **CONCLUSION**

In this last chapter, I will first give a summary of what we have been seen and discussed of the present phonetic study of Tsilhqut'in ejectives (Section 6.1). I will draw conclusions in Section 6.2 based on the overall findings from this study which had been discussed so far in comparison with other early studies of ejectives. Finally, in Section 6.3, I will address the contributions my phonetic study has made and present a number of research goals which I want to pursue further in the near future based on the findings presented herein.

#### **6.1 Summary**

##### **6.1.1 Acoustic Analysis: Intra-language and Inter-language Comparisons**

To recap the acoustic part of the study, the intra-language comparison shows the contrastive results of the four measures that distinguish the ejectives from the other stops in Tsilhqut'in. In contrast to the plain and aspirated stops, the Tsilhqut'in ejectives have longer VOT, greater creaky quality and lower pitch at the voicing onset of a following vowel, and a slower rise of intensity between the 30 ms into and the peak of the vowel. I maintain that if we follow the traditionally advocated binary classification, we run into a problem of not being able to put Tsilhqut'in ejectives into either strong or weak category.

Also, the inter-language comparison between ejectives in Tsilhqut'in and in six other languages – Ingush, Hausa, Quiché, Tigrinya, Navajo, and Witsuwit'en – shows similar results in terms of the value of the strong-weak categorization. That is, according to the results from the four measures of Tsilhqut'in ejectives, Tsilhqut'in cannot be accounted for by the dichotomy since its phonetic characteristics consist of both strong and weak types. Neither can Ingush and Quiché ejectives be classified into a single category for their combined qualities at the phonetic level.

Even the other languages which seem to pattern clearly as strong or weak (i.e. Hausa, Tigrinya, Navajo, and Witsuwit'en) have been reported as diverging from the strict dichotomy on other issues such as showing considerable inter-speaker variation.

#### 6.1.2 Auditory Analysis: Auditory Impressions & Acoustic Characterization

In this analysis, I examined how I perceive Tsilhqut'in ejectives and how my perception would compare with the phonetic characterization determined from the acoustic analysis. In terms of the number of occurrence, although over 77% (i.e. 33 out of 43) of my auditory impressions indicate strong, the other 10 ejectives are perceived as weak or uncertain, comprising the other 23%. This finding indicates that the auditory examination shows mixed results, as the acoustic analysis does.

According to the results from both the acoustic analysis and impressionistic examination, ejectives in the Tsilhqut'in language have a combination of *weak* and *strong* qualities at the phonetic level. In accordance with the findings from other ejective studies (e.g. Warner 1996), in terms of such acoustic measures as VOT, voice quality, pitch, and

intensity, the Tsilhqut'in ejectives show a mixture of results indicating that they do not pattern along the line of the traditional dichotomy. The resulting measurements are in part correlated not just to the strong but also to the weak ejectives.

## 6.2 General Conclusions

Overall, Tsilhqut'in ejectives do not fit into the hypothesized binary classification. The results from the acoustic and auditory analyses show that the strong-weak categorization cannot account for these ejectives since they have a combination of the phonetic properties of the two types.

Accordingly, going back to the research question, one conclusion that we can draw from all the findings and discussions so far is that Tsilhqut'in ejectives are *neither* strong *nor* weak, but *variable*. The present phonetic study bears findings that coincide with what more recent studies (e.g. Warner 1996, Bird 2002, and Wright et al. 2002) have found of ejectives in other languages. The mixed results of both strong and weak types from the acoustic and auditory analyses in this study add further evidence for considerable *variability* of ejectives at the phonetic level across languages.

This entails another inevitable conclusion that the binary classification is neither universal nor categorical and that this traditional dichotomous typology of ejectives needs to be reconsidered. Therefore, we need a better way of classifying ejectives across languages in the world.

### 6.3 Future Directions

It is my hope that what is found of the Tsilhqut'in ejectives through this instrumental study will shed some light on ejective typology and contribute to the field of linguistics. At the same time, I feel obliged to remind readers of issues that the present study encounters so that they can be considered in future research.

For follow-up research in the near future, there are a number of things that I am to investigate so as to improve on, if not eliminate, what count as limitations of the current study. For one, a greater amount of data needs to be analyzed. This can allow each type of ejective to be more even in counts and ultimately can yield results that are more representative of the Tsilhqut'in language. As mentioned earlier, due to the small dataset used in the present study, none of the findings here could be interpreted as absolutely conclusive. They can be used as a foundation on which to base further research.

Further expanded and enhanced investigations are desirable in order to develop a more complete picture of the phonetic nature of the Tsilhqut'in ejectives and to cultivate more precise comparisons between the ejectives in Tsilhqut'in and other languages. One way to enhance the current study will be by employing both articulatory and auditory investigations with a more elaborated acoustic analysis. That is, I plan to carry out extended fieldwork first and then analyze the collected data by using not only acoustical analysis software, but also other articulatory speech analysis techniques such as laryngoscopy (e.g. Esling et al. 2005) and ultra-sound. This will allow me to obtain more complete and precise results. For example, the onset of a stop closure could not be

detected by acoustical analysis software (e.g. Praat) in this study, whereas laryngoscopy will be able to detect such an onset in future study.

Lastly, in general, more research on ejectives in various languages is needed. More concrete information about ejectives in comparison with other types of stops in different languages, such as actual values of VOT (e.g. 67 ms), Jitter Perturbation (e.g. 4%), F0 Perturbation (e.g. 244 Hz), and Rise Time (e.g. 79 dB), will be extremely helpful to make a precise comparison among the sounds under investigation.

To conclude, further extended study of ejectives in various languages is not only desirable but also essential in order to find an optimal way to classify and thereby understand such prevalent sounds in the languages of the world. Therefore, I certainly believe that in spite of the issues and restrictions, the present study adds to the resources for learning and teaching ejective stops – one of the largest classes of sounds across languages. Furthermore, this phonetic study contributes to linguistics by closely and quantitatively examining the problem of ejective typology and searching for a solution. Ultimately, by pursuing further research of the Tsilhqut'in language and possibly other Athabaskan languages, I will continue to participate in efforts being made around the world towards language acquisition and revitalization.

## REFERENCES

- Beck, David. 2006. "The Emergence of Ejective Fricatives in Upper Necaxa Totonac." Robert Kirchner (Ed.) *University of Alberta Working Papers in Linguistics vol. 1*, 1-18.
- Bird, Sonya. 2002a. "Dakelh Ejectives: Evidence for New Ways of Classifying Sounds." 76<sup>th</sup> Meeting of the Linguistic Society of America. San Francisco, CA.
- Bird, Sonya. 2002b. *The Phonetics and Phonology of Lheidli Intervocalic Consonants*. Ph.D. dissertation. University of Arizona, Tuscon.
- Bird, Sonya. 2004. "Lheidli Intervocalic Consonants: Phonetic and Morphological Effects." *Journal of the International Phonetic Association*. 34, 69-91.
- Esling, John H. (2005). "How the Pharyngeal Resonator is controlled Articulatorily." *Journal of the Acoustical Society of America*. 117, 2489.
- Esling, John H., Barry F. Carlson, and Jimmy G. Harris. 2002. "A Laryngoscopic Phonetic Study of Nootka and Salish Glottal Stop, Glottalized Resonants, and Pharyngeals." Paper presented at the SSILA conference, January 2002. San Francisco.
- Esling, John H. and Jimmy G. Harris. 2005. "States of the Glottis: An Articulatory Phonetic Model Based on Laryngoscopic Observations." *A Figure of Speech: A Festschrift for John Laver*: 347-383. W. J. Hardcastle & J. Beck (Eds.): Mahwah, NJ: Lawrence Erlbaum Associates.
- Esling, John H., Katherine E. Fraser, and Jimmy G. Harris. 2005. "Glottal stop, Glottalized Resonants, and Pharyngeals: A Reinterpretation with Evidence from a Laryngoscopic Study of Nuuchahnulth (Nootka)." *Journal of Phonetics*. 33, 383-410.
- Gessner, Suzanne. 2003. *The Prosodic System of the Dakelh (Carrier) Language*. Ph.D. dissertation. University of British Columbia.
- Glass, Gene V. and Kenneth D. Hopkins. 1995. *Statistical Methods in Education and Psychology*. Boston: Allyn and Bacon.
- Ham, SooYoun. To appear. "Tsilhqut'in Ejectives." *Proceedings of the 2007 Canadian Linguistic Association Annual Conference*.
- Hargus, Sharon. 2007. *Witsuwit'en Grammar: Phonetics, Phonology, Morphology*. Vancouver, B.C.: UBC Press.

- Helm, June. 1981. "Technical Alphabet." *Handbook of North American Indians vol. 6, Subarctic*. June Helm (Ed.). Washington, D.C.: Smithsonian Institution.
- Holton, Gary. 2000. *The Phonology and Morphology of the Tanacross Athapaskan Languages*. Ph.D. dissertation. University of California, Santa Barbara.
- Holton, Gary. 2001. "Fortis and Lenis Fricatives in Tanacross Athapaskan." *International Journal of American Linguistics*. 67: 396-414.
- IPA. 1999. *Handbook of the International Phonetic Association: A guide to the use of the International Phonetic Alphabet*. Cambridge: Cambridge University Press.
- Kent, Raymond D. and Charles Read. 2001. *Acoustic Analysis of Speech*. 2<sup>nd</sup> ed Singular; Albany, NY.: Thomson Learning.
- Kingston, John. 1985. *The Phonetics and Phonology of the Timing of Oral and Glottal Events*. Ph.D. dissertation. University of California, Berkeley.
- Krauss, Michael. 1975. *Chilcotin Phonology, A Descriptive and Historical Report, with Recommendations for a Chilcotin Orthography*. University of Alaska. MS.
- Krauss, Michael E. and Victor Golla. 1981. "Northern Athapaskan Languages." *Handbook of North American Indians vol. 6, Subarctic*: 67-85. June Helm (Ed.). Washington, D.C.: Smithsonian Institution.
- Ladefoged, Peter and Ian Maddieson. 1996. *The Sounds of the World's Languages*. Oxford: Black.
- Lane, Robert B. 1981. "Chilcotin." *Handbook of North American Indians vol. 6, Subarctic*: 402-412. June Helm (Ed.). Washington, D.C.: Smithsonian Institution.
- Laver, John. 1994. *Principles of Phonetics*. Cambridge: Cambridge University Press.
- Lindau, Mona. 1984. "Phonetic Differences in Glottalic Consonants." *Journal of Phonetics*. 12, 147-155.
- MacEachern, Margaret R. 1996. "Computer modeling of the Production of Ejectives Using Aerodynamic and Acoustic Data." *Journal of the Acoustical Society of America*. 100, 2661.
- Maddieson, Ian. 1998a. "Strength Matters?" *UCLA Working Papers in Phonetics*. 96, 1965-1968.
- Maddieson, Ian. 1998b. "Why Make Life Hard? – Resolutions to Problems of Rare and Difficult Sound Types." *UCLA Working Papers in Phonetics*. 96, 106-118.

Maddieson, Ian, Nicola Bessell, and Caroline Laws Smith. 1996. "A Preliminary Report on the Phonetics of Tlingit." *UCLA Working Papers in Phonetics*. 93, 125-148.

McDonough, Joyce. 2003. *The Navajo Sound System*. Dordrecht, the Netherlands: Kluwer Academic Publishers.

McDonough, Joyce and Peter Ladefoged. 1993. "Navajo Stops." *UCLA Working Papers in Phonetics*. 87, 151-164.

Mithun, Marianne. 1999. "Athabaskan-Eyak-Tlingit Family." *The Languages of Native North America*. Cambridge: Cambridge University Press.

Rice, Keren and Sharon Hargus. 2005. Introduction. *Athabaskan Prosody*. John Benjamins: Philadelphia and Amsterdam.

Russell, Susan and Maria Myers. 2005. *Instructor's Handbook a Guide to Chapters 1 – 3 of E.D. Cook's a Linguistic Instruction to Tsilhqut'in* (Chilcotin). Simon Fraser University. MS.: Tsilhqot'in National Government.

Story, G. L. 1984. *Babine & Carrier Phonology*. Dallas, Tex.: Summer Institute of Linguistics.

Tłıchq Yatì Multimedia Dictionary. 2005. <http://tlicholinguistics.ca>. L. Saxon & M. Siemens (Eds.): Behchokò: Tłıchq Community Services Agency.

Tuttle, Siri G. 1998. *Metrical and Tonal Structures in Tanana Athabaskan*. Ph.D. dissertation. University of Washington, WA.

Warner, Natasha. 1996. "Acoustic Characteristics of Ejectives in Ingush." *Proceedings of the International Conference on Spoken Language Processing*: 1525-1528. Philadelphia, PA.

Warner, Natasha and Takayuki Arai. 2001. "The Role of the Mora in the Timing of Spontaneous Japanese speech." *Journal of the Acoustical Society of America*. 109, 1144-1156.

Warner, Natasha, Allard Jongman, Joan Sereno, and Rachel Kemps. 2004. "Incomplete Neutralization and Other Sub-phonemic Durational Differences in Production and Perception: Evidence from Dutch." *Journal of Phonetics*. 32, 251-276.

Wright, Richard, Sharon Hargus, and Katharine Davis. 2002. "On the Categorization of Ejectives: Data from Witsuwit'en." *Journal of the International Phonetic Association*. 32, 43-77.

## APPENDIX

## List of Ejective Tokens in Tsilhqut'in

Token	Orthography	Transcription	Gloss
/t'/			
1	nendenedī(n)lht'i	nændɛnɛdīɬt'ɛɪ	s/he closed the entrance (door, gate)
2	nendenedī(n)lht'i	nændænæd̥ɪlt'i:	s/he closed the entrance (door, gate)
3	xents'agughelht'ih	xənts'ægowəɬt'i	you (pl.) prayed
4	xents'agughelht'ih	xənts'ægo:ɬt'ih	you (pl.) prayed
5	jiʔadest'in	dʒiʔædɛst'in	I began
6	jiʔadest'in	dʒiædæst'in	I began
7	hunilht'ah	huniɬt'æh	how are you?
8	set'a	sɛ' t'æ:	my wings
9	seʔanest'ih	sə.ʔænɪs' t'ɪh	I'm doing well
/ts'/			
10	belhadelhts'ish	bɛɬædɛɬts'ɪç	s/he/it is yawning
11	belhadelhts'ish	bɛɬædɛɬts'ɪç	s/he/it is yawning
12	hi(n)lhts'ugh	xiɬts'ao:	you (sg.)/I mixed it (liquid batter)
13	hi(n)lhts'ugh	hiɬts'o:y	you (sg.)/I mixed it (liquid batter)
14	belhadežinlhts'ish	bɛɬædɛɬʒejɬts'eɪh	you yawned
15	belhadežinlhts'ish	bɛɬædɛɬʒejɬts'eɪh	you yawned
16	ts'i	ts'ɪ:	boat
17	seʔimba nents'in	sɛʔi:m' bæ: nɪnts'ɪi	where is my dad?
18	sets'i	sɛ' ts'ɪ:	my boat
/tʃ'/			
19	sech'an	sɛtʃ'an	before me (as in "before my time")
20	sech'an	sɛtʃ'æn	before me (as in "before my time")

21	ts'ed ch'ededan ch'ed tešelhchuž	ts'ét tʃ'ɛræ:n tʃ'ɛt thɫsɫ 'tʃó:l̩z	s/he is putting a blanket on the table
22	ts'ed ch'ededan ch'ed tešelhchuž	ts'ét tʃ'ɛræ:n tʃ'ɛt thɫsɫ 'tʃó:l̩z	s/he is putting a blanket on the table
23	debi betšigha ch'ededan ch'ed selex	dɛbi bətsəj 'jɑ: tʃ'ɛræ:n tʃ'ɛt səlax	there's some mountain goat hair on the table
24	debi betšigha ch'ededan ch'ed selex	dɛbi bətsəj 'jɑ: tʃ'ɛræ:n tʃ'ɛt səlax	there's some mountain goat hair on the table
25	bech'ed	bɛtʃ'ét	on it
/tʃ'/			
26	bateghetaghentl'ox	bɫthɫwəthæntʃ'oʷx	are you going to set a snare for it?
27	bateghetaghentl'ox	bæthəyətha:ntʃ'uʷ	are you going to set a snare for it?
28	tl'ulh	tʃ'uɫ	rope
/k'/			
29	ʔek'ex	ʔək':ɫx	lard
30	ʔek'ex	ʔək':ɫx	lard
31	k'a	k'æ	arrow
32	k'a	k'æ	arrow
33	gweninq'ez	gʷɫnĩ: 'k'ɫl̩z	it is cold
34	k'i ʔet'an ʔigut'in	k'i: ʔét'æn ʔi:gút'in	green willow
35	ʔabenax nentasʔinlh k'es džanaš	ʔæbənæ:h nɪnthæsʔiŋɫ k'ɛs džana:s	I will see you (sg.) in the morning or noon.
/q'/			
36	ninq'ez	nĩ:q'ɫ(:)	it is cold
37	ninq'ez	nĩ:q'ɫ	it is cold
38	gwezq'ez	gʷæɫq'ɫl̩z	it is cold; cold weather
39	gwezq'ez	gʷæɫq'ɫ	it is cold; cold weather
/kʷ'/			
40	kw'elh	kʷ'ɫ	penis

41	kw'eš/qw'es	k <sup>w</sup> ʌs	cloud
42	kw'es/qw'es	k <sup>w</sup> ʌs	cloud
43	kw'es/qw'es	k <sup>w</sup> əʌs/k <sup>w</sup> ʌs	cloud(s)

### Notes on Appendix

- 17            The last nasal vowel [ɪ̃] could also be transcribed as [ɲ].
- 18            This word also means 'my intestines.'
- 19 & 20       This word also means 'physically ahead of me.'
- 21 & 22       This could also be translated as 's/he put a blanket on the table.'
- 23 & 24       The approximant [j] in [jɑ:] could also be transcribed as [ɣ].  
Another translation could be 'the mountain goat's hair is sitting on the table.'
- 25            The fricative [x] could also be transcribed as [ç].
- 34            This could also be translated as 'the willow is green.'
- 40            The vowel [ʌ] could also be transcribed as [ɛ] or [ə].