PITCH AND VOICE QUALITY:

ACOUSTIC EVIDENCE FOR TONE IN LOWER KOYUKON

By

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Abstract

This thesis addresses the acoustic realization of tone in the Lower dialect of the Koyukon language. The Lower dialect is the only one of the three Koyukon dialects attested to have tone. Its exact nature, however, remains unclear. This study seeks to corroborate previous attestations of low tone in Lower Koyukon by providing acoustic evidence of its realization. Therefore, there are three primary objectives: a) to determine how tone is produced in Lower Koyukon with respect to pitch; b) to examine any interactions between tone and potential pitch-altering phenomena; and c) to determine the realization of creaky phonation during tone production, if such exists.

All of the data for this study was gathered from a single consultant, a fluent Lower Koyukon speaker. Three elicitation strategies were employed. First, a game of bingo was developed from a list of words predicted to carry a tonal syllable. Second, the consultant was asked to teach the researcher how to pronounce a series of short phrases and sentences that contained a word with a tonal syllable. Finally, the researcher selected a story written in Koyukon for the consultant to read aloud.

During the analytical process, each word predicted to carry tone was compared to both a control set of non-tonal words and a set of words that may or may not carry tone. The only statistically significant difference was that the set of tokens predicted to carry tone had higher measures of creak than the control set. As creaky voice is inherently linked to tone production, this finding supports previous attestations of tone. However, both quantitative and qualitative methods were employed for this study, and several examples are cited which show both that there is a significant pitch change on syllables predicted to carry tone. Moreover, it appears that that this pitch rises. The implications of this study are therefore that tone is present in modern Lower Koyukon, and that this tone may by high, rather than low, as has been previously claimed.

Table of Contents

Page

Title Page i

Abstract iii

Table of Contents v

List of Figures vi

List of Tables vii

List of Appendices viii

Acknowledgments ix

1. Introduction 1

2. Background 7

2.1 Athabaskan Tone 7

3. Methodology 15

3.1 Data Collection 15

3.2 Analytical Methods 24

4. Results 27

5. Discussion 31

6. Conclusion 43

7. Bibliography 45

Appendix A 47

Appendix B 53

List of Figures

Page

Figure 1: Map of the Koyukon language area, via Jones and Jetté 2000, p. xlvix. Used by permission. 1

Figure 2: Development of tone systems (Krauss & Golla 1991:70) 10

Figure 3: Sample bingo elicitation cards. 23

Figure 4: Visual representation of data organization 28

Figure 5: A pitch mapping of token 233 33

Figure 6: A pitch mapping of token 0050 34

Figure 7: A pitch mapping of token 243 37

Figure 8: A pitch mapping of token 251 39

List of Tables

Page

Table 1: The full primary wordlist, a series of nine tables corresponding to Krauss (1979)'s breakdown of tone developing environments. Any blank spaces were left blank as the dictionary did not provide those target words embedded in phrases. 16

Table 2: The full secondary wordlist. 21

Table 3: The control set, terms that were mixed at random into the first elicitation task. These are meant to provide tokens where tone is not predicted to appear: they do not appear on Krauss' wordlist above, nor were they glottalized in PA reconstructions. All were selected from the Koyukon Athabaskan Dictionary (Jones and Jetté 2000). 22

Table 4: Variable values for task one tokens 29

Table 5: Summary of t-test results. Outcomes where the p-value was less than .05 are in bold 30

Table 6: A breakdown of task two elicitation data, where each token has one syllable expected to carry tone. The "Predicted Pitch Contour" column describes the pitch for each syllable in the word as predicted by Krauss. Note that this contour only describes the potential lexical tones within each word, and not any suprasegmental interference from stress and intonation 36

Table 7: A breakdown of task two elicitation data, where each token has two syllables expected to carry tone 40

List of Appendices

Page

Appendix A 47

Appendix B 53

Acknowledgments

The fieldwork for this project would not have been possible without the generosity of the Nulato community. I would like to extend heartfelt gratitude to Susan Paskvan for allowing me to travel with her and for introducing me to the community elders; to Eliza Jones, without whose extensive language work and invaluable input during early elicitation sessions it would have been very difficult to navigate *tl'eeyegge hukkenaage'* (Koyukon language); to my wonderful consultant Paulina Stickman; to Martha Demoski, whose notes and transcriptions of Miss Paulina's language were infinitely helpful; and to the coordinators and administrators at the Andrew K. Demoski School in Nulato, for giving me a place to stay and hub of operations during my fieldwork.

1. Introduction

There are three dialects of the Alaskan language Koyukon: Upper, Central, and Lower. The lower dialect of Koyukon is critically endangered. It is still spoken in at least two villages along the Yukon River, Nulato (pop. 259) and Kaltag (pop. 185). When asked about the state of the language during a preliminary field trip, many Nulato residents interviewed lamented the dwindling use of the language, each citing the same small handful of speakers still in town. With each name came an account of every time each fluent elder had been recently medevac'd out of town for a medical emergency, as though to underscore the dire situation of the lower dialect of Koyukon. With the last speakers advancing in age, it seems that the people of Nulato are resolved to spend what time they have left with them learning whatever they can.

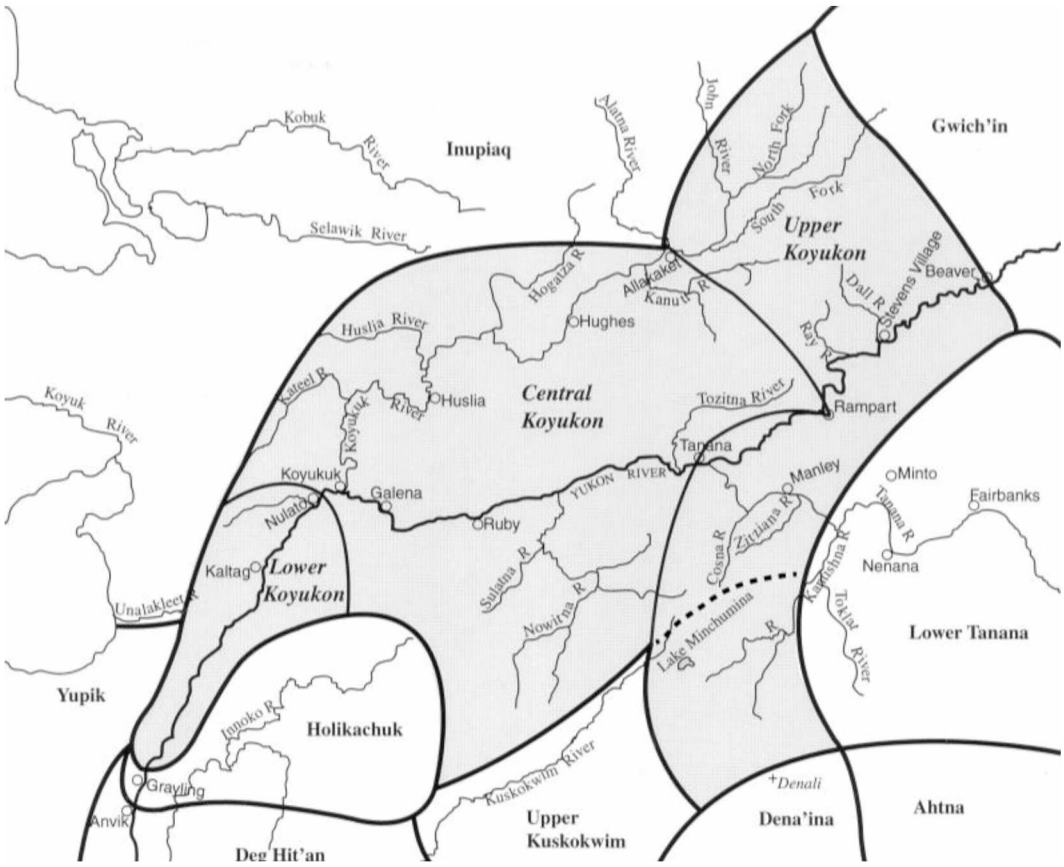

Figure 1: Map of the Koyukon language area, via Jones and Jetté 2000, p. xlvix. Used by permission.

For many years now, there has been a government-funded effort to maintain the language through classroom instruction. With this funding have come teachers, learning materials, and the hope that another generation of Lower Koyukon students may learn the language. These materials, however, are designed to be useful for learners of all three major dialects and thus are not meant to be dialect-specific. Based on my observation of and conversation with very competent and talented Koyukon teachers that work in the area, they are mindful to change how they speak when dealing with students in different dialect areas; nevertheless, while many residents in Nulato are aware of the most salient features that define the Lower dialect, there are "invisible" features that have no grammatical consequence. It is unclear if speakers consider these to be important aspects of their local dialect. One such "invisible" feature is tone. Lower Koyukon is the only one of the three dialects that has retained tone (Jones and Jetté 2000). However, tone is neither well-attested nor represented in the alphabet or teaching materials.

The Koyukon community has significant language resources[1]. There exists a very thorough dictionary, a combination of the efforts of Jules Jetté and Eliza Jones (Jones and Jetté 2000). There are also community-internal efforts to revitalize the language, including school programs to pass on the language to children. However, most of the materials focus on the dominant Central dialect. Among Koyukon researchers, the presence of tone in the Lower dialect is well-known, despite the lack of documentation. Eliza Jones, prolific linguistic researcher, Koyukon speaker and language expert, and author of the Koyukon Athabaskan Dictionary, upon the mention of tone immediately commented on its enigmatic nature in Koyukon. This thesis seeks to clarify some of that mystery by investigating the acoustic properties of low tone in Lower Koyukon. The primary objectives of this project are: a) to determine whether low tone is produced in Lower Koyukon with respect to

[1] Extra reference materials for the IPA vowels and consonants of Koyukon and their orthographic forms can be found in Appendix B.

pitch; b) to examine any interactions between low tone and potential pitch-altering phenomena, such as intonation; and c) to determine the realization of creaky phonation during low tone production, if such exists.

Many of learning materials for language learners are based on field research for the Koyukon Dictionary by Jones and Jetté (2000). However, while Jetté lived and worked in Nulato, a Lower Koyukon speaking region, he did not document tone in his work. Eliza Jones, meanwhile, is a Central Koyukon speaker. Because of this, little scholarly attention has been given to documenting tone in Lower Koyukon. While the existence of tone in Lower Koyukon has been suggested by in Jones' comments and is attested in the work of Krauss and Kingston, based on current literature, it is unclear both how widespread it is in Lower Koyukon and how it presents acoustically (Jones and Jetté 2000, Krauss 1979, Kingston 1985, 2005).

Nevertheless, based on Krauss (1979) and Kingston (2005) it is predicted that tone in Lower Koyukon will present similarly to how it presents in some other Athabaskan languages: that is to say, a tone with significant creaky phonation across the syllable. Kingston, basing his analysis on previous work by Leer (1979, 1999, 2001), proposes several methods by which tone may have developed in Athabaskan languages, but consistently the trend is that tone is closely related to creakiness, which is in turn related to proto-Athabaskan glottalization. Therefore, we expect to find that creakiness has been supplanted by tone in tone-carrying syllables that are not followed by a glottalized consonant.

The consultant for this study was recruited in Nulato, Alaska. She is a fluent L1 speaker of Lower Koyukon. Accompanying her was a facilitator, a lifetime student of the language who would assist both the researcher and consultant throughout the study. The elicitation tasks were as follows: an interview, a bingo game, a story task, and a word list task. The interview was intended

only to gather biographical information and get the consultant comfortable with the linguistic tasks. In the bingo task, the participants were asked to play a version of bingo in which the squares are filled with nouns expected to contain the target tone. They then alternated moderating the game, while the researcher recorded the moderator calling out the words. Finally, the consultant was asked to read a word list and a story aloud.

Once data collection was complete, tokens— the isolated vowels of the target words— were organized according to certain characteristics: for example, whether or not the word was stressed, where it occurs in an intonational contour, and if it was spoken in isolation. Low tone vowels beside an ejective/glottalized consonant and low tone vowels not beside a glottalized consonant were also separated. The primary analysis was of the f0 of the target vowels. F0 measurements were taken at the 20%, 50%, and 80% marks, to account for the beginning, middle, and end of the vowel duration. Measures of shimmer and jitter were also taken across the vowel duration to account for phonation throughout the segment over time.

It is predicted that the Lower Koyukon data will show evidence of tone. Because Koyukon low tone has been claimed in previous literature (Jones and Jetté 2000:lviii), this project predicts that the tone will be shown to be low.

Applications for this research are primarily pedagogical and sociolinguistic in nature. Most learning materials for the language are based on Central Koyukon, which does not have tone. In terms of pedagogy, then, an illustration of how tone works in Lower Koyukon will help learners of the dialect. Furthermore, many speakers of Athabaskan languages are not interested so much in strict dialect and language boundaries, but rather in how people speak in one specific area versus another. This is often a means of social alignment: for example, to speak using features of the Lower dialect is to associate oneself with downriver villages. To better outline what defines a

Lower Koyukon speaker from Nulato specifically is then work that lends itself to the revitalization of ethnic identity through language.

2. Background

2.1 Athabaskan Tone

Tone in Athabaskan languages has been primarily discussed by linguists due to its contradictory nature. In the languages in which it appears, it surfaces consistently in the same places; however, in some languages, there is only low tone, while in others, the tone on the same stem is high. These observations were first made by Li with respect to Chipewyan in 1928 and 1929 work with Hare. These observations countered previous ideas about tone established by Sapir's documentation of Navajo-Tsuut'ina-Gwich'in (Krauss 1979:5). More recently, Krauss writes, "the Navaho reflexes of full vowels consistently have high tone where Chipewyan has low, and low where Chipewyan has high (Sarcee follows the Navaho in this)" (Krauss 1979:8).

It is worth noting here that while Krauss in his forward to the Koyukon Athabaskan Dictionary claims that Lower Koyukon tone is low (Jones and Jetté 2000:lviii), when talking with Eliza Jones about the project, she asked why we referred to the local tone as low. Because tone in Lower Koyukon has not been completely described, it is not clear to a non-speaker whether Lower Koyukon tone surfaces as low or high. It also may be possible that Krauss' consultants did produce a low tone, and due to any number of factors, the remaining speakers of Lower Koyukon produce a high tone. Finally, it may be the case that factors in the linguistic environment condition underlying tone to surface as high or low. In either case, tone is certainly a feature that local language experts are aware of, even if its exact nature is unclear (Jones and Jetté 2000:lxxx).

Phonetically speaking, tone is realized as a change in F0 during a certain syllable. Cross-linguistically, tone generally has a lexical or grammatical purpose, and tone systems are common. While tone can be grammatical, in Lower Koyukon it is lexical. A grammatical tone is a contrastive feature, whereas producing one pitch level over another changes the meaning of the word, as is the

case in Vietnamese (Brunelle 2009). Lexical tone, on the other hand, is the distinctive pitch on the syllable of a word that is an essential to the meaning of that word (Li & Chen 2015). If tone in Lower Koyukon today is a non-productive feature from an earlier form of the language, this tone may be relatively unimportant to the expression of meaning: failure to produce tone does not elicit a different or nonsensical meaning. Furthermore, speakers don't seem likely to correct failure to produce tone, because if it has no grammatical function, they may not be aware that they produce tone at all.

The story of tonogenesis in Athabaskan is long and complex. Leer (1979) offered the first fundamental step to come in the contemporary understanding of Dene tonogenesis, the first proposal of widespread stem-final glottalized occlusive in Proto-Athabaskan. This was a segment of his monograph *Proto-Athabaskan Verb Stem Variation Part One: Phonology*, the goal of which was to provide an explanation of stem variation across the Dene family. The processes he describes, including tonogenesis, vocalic nasalization, and stem vowel ablaut, form the core of histheory of suprasegmentalization. *Suprasegmentalization* refers to a number of closely-related processes that occurred during the transition from Pre-Proto-Athabaskan to Proto-Athabaskan, and set the stage for tonogenesis.

Leer claims that one step suprasegmentalization is the evolution of the post-vocalic, coda-position glottal into an alternative phonation type. This is not to say this constriction occurred wherever a glottal followed a vowel; rather, it "results in part from the delinking of the feature [glottalization] from a postvocalic glottalized stop or glottalized segment and reassociation of this feature leftward, to the preceding vowel" (Leer 1999:52). In other words, constriction is a phonation type that occurs when glottalization separates itself from a post-vocalic coda-position

glottalized segment and spreads over the preceding vowel. In this way, constriction is suprasegmental, 'floating above' the vowel, rather than being tied to a coda consonant.

The occurence of certain stems bearing constriction has resulted in two identical, if opposite, systems of tone in different languages. In high-marked tone languages, constriction appears as high tone, while in low-marked tone languages, it surfaces as low tone. However, there are significantly more low-marked languages in the Athabaskan family than high-marked, leading Leer to hypothesize that the low-marked system is possibly older than the high-marked. High-marked tone may therefore be an evolution of low-marked tone, spread geographically (Leer 1999). There does appear to be a geographical relationship among the tone-marked languages: while the spread of low-marked languages is vast, the high-marked languages are largely contiguous. This is illustrated in Figure 2 below.

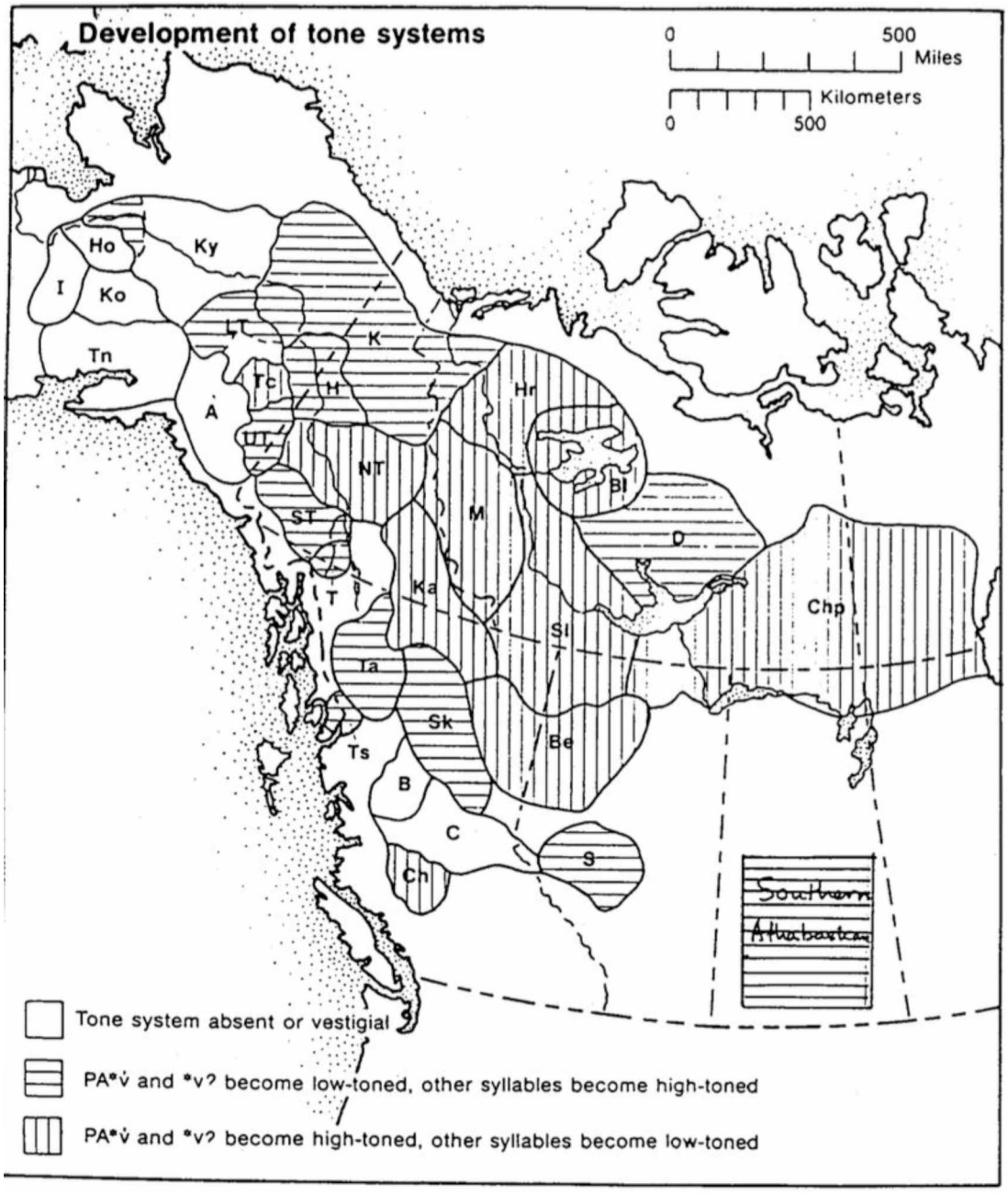

Figure 2: Development of tone systems (Krauss & Golla 1991:70)

The notable exception is the only Alaskan language that is marked for high tone, Tanacross. It is surrounded by low-tone languages, including a close relative, Upper Tanana. In this map,

Koyukon's tone is correctly identified as 'absent or vestigial'— it has no grammatical bearing, and any traces of it that exist in any dialect are "fossil records" of tonogenesis in PA.

Predictions regarding the research questions for the present project come from Krauss (1979) and Kingston (2005), both of whom discuss tone and tonogenesis in Athabaskan languages. The aim of Krauss (1979) is to present a general mapping of tone for this language family, although only nouns are discussed. There are several reasons for this: more nominals are documented and verbs are more morphologically complex (Krauss 1979:1). Based on Tsuut'ina data, Sapir (1914) initially claimed that Proto-Athabaskan (PA) was likely tonal. Krauss takes this farther, citing Sapir's claims that PA probably had several tone registers, high and low (Krauss 1979:3). Li (1930b) claims that a low-tone vowel in open syllables is regularly followed by a glottal stop, a statement generalized from Sarcee, Gwich'in, and Navajo data. In all of these languages, low tone is followed by a glottal stop. However, neither Li nor Sapir address Athabaskan languages like Chipewyan or Hare, in which high tone precedes glottal stops.

Krauss extrapolates a basic sketch of PA phonology based on data collected by other researchers and concludes that tone was likely not phonemic in PA (Krauss 1979:8). Tone, it seems, was phonetically conditioned by the presence or absence of glottalization. Furthermore, Krauss cites examples such as Northern and Southern Tutchone, which are highly mutually intelligible despite opposite tones and imply that tones are important, but may not be decisive for intelligibility when other linguistic factors are favorable.

The principle goals of Kingston (2005) are similar to Krauss (1979), insofar as both attempt a sketch of PA based on existing Athabaskan data. However, Kingston's objective is specifically to explain why some Athabaskan languages have high tone while others have low, based on foundational materials and data collected by Leer (1979, 1999, 2001). He states that distantly-

related Athabaskan languages are descended from different dialects of PA, where speakers pronounced stem-final glottalic consonants differently.

Kingston divides the Athabaskan family into four groups: the Pacific Coast, which carries no tones; the non-tonal languages of southcentral Alaska and western British Columbia; the tonal northern Athabaskan languages of northwestern Canada and Alaska; and tonal Apachean languages. However, tonal developments do not correspond to these groups; this grouping does not necessarily correspond to the manifestation of tone. As such, Kingston proposes two subgroups of the family: languages in which tone didn't evolve from stem-final glottalic consonants, and languages where it did. This latter group contain communities of speakers who pronounced stem-final glottalic consonants so as to raise or lower the F_0 on preceding vowels. Thus, tone evolved as a shift of the glottalic articulation of the stem-final consonant to the preceding vowel in the form of a distinctive, non-modal voice quality (Kingston, 2005).

The introduction of non-modal (specifically, creaky) voice quality is fundamental to the modern understanding of Athabaskan tonogenesis. Leer (1999) cites Li (1933:458) in saying that "it may be remarkable that the high-toned forms here [recall that in Chipewyan, the high tone is the *marked* tone] are not accidental. They are intimately connected with the glottal stop which has been lost." Krauss (1964:123) expands upon the connection between tone and creak:

> Tone was probably not phonemic as such in PAE [Proto-Athabaskan-Eyak], or even in PA. It is absent in Eyak, where a system of vowel modifiers is found instead. The Navaho reflexes of full vowels consistently has high tone where Chipewyan has low, and low where Chipewyan has high. (Sarcee follows Navaho in this.) Because of the phonetically opposite reflexes in Chipewyan and Navaho, it would seem unlikely that the prototype could have

been pitch-level. Perhaps it was a two-level stress system, or perhaps it was phonetically conditioned at least in great part by the absence or presence of *? in T [T here represents Krauss' reconstruction of the post-vocalic elements of the stem in PA], with which it is certainly intimately connected.

Kingston further proposes that both high and low tone could come from creakiness. Following the principal intensity peak of the creaked syllable, several lower-intensity peaks (or 'subpulses') may occur within a non-modal glottal cycle. The resulting air pressure variations above the glottis are then partially out of phase, and partially cancel one another out. This intensity modulation within a cycle could affect pitch: if the subpulses are much weaker than the principle intensity peak, then the pitch would be lower. If they were close to the principle intensity peak, the pitch would be higher (Kingston 2005:28). This is a process by which high and low tones can develop from the same source.

3. Methodology

3.1 Data Collection

This thesis is a production study, intended to elicit words and phrases with syllables that are predicted to contain the target tones and provide acoustic evidence to corroborate previous claims about tone in Lower Koyukon. The consultant for this study was recruited in Nulato, Alaska. There is not at this time a comprehensive list of environments where tone can be found in Lower Koyukon, outside of a brief section in Krauss' introduction to the Koyukon Athabaskan Dictionary. For this reason, two words lists were constructed.

The first, displayed as a series of tables in Table 1 below, is based on word lists for other Athabaskan languages whose tonal systems are better understood. This word list corresponds to Krauss' breakdown of environments for tone development in a swath of Athabaskan languages (Krauss, 1979:22-50). That is to say, each of the nine categories in Table 1 are composed of syllable types that Krauss predicted could result in low tone. Terms that were removed from the original tables include inalienable nouns (e.g., kinship terms and body part words). This is because the construction of these words in Koyukon may yield stress or tonal patterns that cannot be controlled for yet. Also removed were terms for 'lake', 'river', 'stone', 'snow', 'fish', 'cloud', 'egg', and 'metal', all of which could produce any one of several terms, 'fox,' as it was included in a separate list (Table 2 below), 'excrement,' as its usage was mostly pejorative, and 'flour,' as it is a Russian loanword. Each term that has a Proto-Athabaskan reconstruction with a glottal in the Koyukon Athabaskan Dictionary has been marked with an asterisk (Jones and Jetté 2000). These asterisk-marked terms are words that are most expected to yield tone.

The first word list was translated from English using the Koyukon Athabaskan dictionary. This dictionary was written primarily for the Central dialect. Thus the consultant corrected several

pronunciation and spelling discrepancies to fit the Lower dialect. Please refer to Appendix A for the revised word list.

Table 2 is a secondary word list composed of terms, phrases, and short sentences taken directly from Krauss' introduction on pages lvi-lvii of the Koyukon Athabaskan Dictionary (Jones & Jetté, 2000). These are all predicted to carry tone on any syllable marked as <V̀>. The corrected version can also be found in the Appendix. Koyukon uses orthography that is common for the family: <ɬ> is used for the voiceless lateral fricative /ɬ/ and <'> represents a glottal. The glottal may be present as a phone of its own (/ʔ/), or as a part of a phoneme, as in glottalized consonants such as <tl'>.

Table 1: Categories 1 to 9: The full primary wordlist, a series of nine tables corresponding to Krauss (1979)'s breakdown of tone developing environments. Any blank spaces were left blank as the dictionary did not provide those target words embedded in phrases.

Category 1: Non-constricted full vowel stems, open and sonorant-closed			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
Sky	yo	the northern lights are shining	yo yekkoyh det'aanh
Water	too	the water is shallow	too negudze
Sun	ghe'ole		
Grease	haa	I am frying it in grease	haa yee etlt'aał
Day	dzaanh	It is day	dzaanh hoolaanh
Rain	konh, konh too	It looks like rain	konh kk'e hu̵naal'onh

Table 1 (Cont.)

Category 1: Non-constricted full vowel stems, open and sonorant-closed (cont.)			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
*Mosquito	tl'eeyh	A swarm of mosquitos came out.	tl'eeyh lek'eł

Category 2: Non-constricted full-vowel stems closed with plain obstruent			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
*Ochre	tseeyh		
*Sand	łaats		
Coat	de'aak		
Rope	tl'ooł	His rope is there	Betl'oole naaldlo

Category 3: Non-constricted full-vowel stems closed with glottalized obstruent			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
*Moss, scum, algae	tl'otl	He is walking on the moss	tl'otl kkokk'e ghehoł
*Scab	łoot	It is covered with a scab, it is scabbed over	bełootneetonh
*Diaper moss, cradle	tl'otltseł		

Table 1 (Cont.)

Category 3: Non-constricted full-vowel stems closed with glottalized obstruent (cont.)			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
*Spit	saakk	he rubbed [the wound] with spit	saakk aahaa eeyet helneek

Category 4: Non-constricted reduced-vowel stems: closed with sonorant vs. closed with obstruent			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
Ice	tenh	The ice is thick.	Tenh deedaakk.
Stick	dekenh	There are no trees.	Dekenh kkelaa
Trail	tene	I'm walking on his trail	Beten ghesoł
Smoke	łet	Smoke is coming out of there	Hołeghee'o

Category 5: Constricted full-vowel stems: open			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
Beaver	kedet'egge		
Louse	yo'	I am lousy (lice are eating me)	Yo' sehonh
Arrow	kk'o'		

Table 1 (Cont.)

Category 6: Constricted full vowel sonorant-closed			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
*Leaf	t'on'	Birch leaves are falling	k'eeyh t'on' nodedaał
*Roe	kk'oon'	His mother ate fish eggs	baanh yets'e kk'oon' gheehon'

Category 7: Constricted full-vowel stems: closed with obstruents			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
Mat	taał		

Category 8: Constricted full-vowel stems: closed with obstruents			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
*Pitch	dzaah	It is pitch (soft, malleable)	dzaah nelaanh
*Fog	okk	It is foggy	okk hoolaanh
*Dish	tl'ok	They take turns giving each other a dish of food	neełts'e tl'ok dehel'aanh

Table 1 (Cont.)

Category 8: Constricted full-vowel stems: closed with obstruents (cont.)			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
Charcoal	t'aas	it [wood] is covered in charcoal (and not burning well)	baat'aas'ooghedenaadlegheł
*Knot	yots	I snared it	mek'elesyots

Category 9: Constricted reduced-vowel stems: closed with sonorants CvC'			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
*Star	tloon'	there are shooting stars	tloon' k'etek'aayh
*Handle, bow	ten'	it has a handle	beten' hoolaanh
*Fire	kkun'	he saw a fire, a falling star	kkun' negheeł'aan'
Cane	ggestl	fire poker	kkun' ggestl

Table 2: The full secondary wordlist.

Page lvi, lvii Koyukon dictionary	
Term (ENG)	Term (LK) – Predicted Tone
‘he went’	tàałeyo
'he went back'	notàałeyo
'he'll go across'	nòtohoł
'he'll go back across'	nònotodoł
'he went back across'	nònotàałeyo
'he walked into the water'	tògheeyo
‘he started to walk into the water’	tòtàalyo
'he's sitting in it'	yeyèeldo
'sit in it'	meyèe leedo
'he went with me'	seyèl tàalyo, sèel tàalyo
'he'll go with me'	seyèl tohol, sèel tohol
'he'll walk with the aid of it'	yet'ò tohol
'he'll start off with the aid of it'	yet'ò tàalyo
'he'll go there',	hèts'èn' tohol
'he started off there',	hèts’èn' tàalyo
'he'll go from there'	hèts'enh tohol
'he started off from there'	hèts'euh tàalyo
'frog’	nòghʉy
'fox'	nàanggedle, nòhmaay, kaagholggʉy
‘black fox’	delzen

‘lynx’	nòdooy, kaazen
'will he buy it?'	yootokkàadèe'
'will he go back?'	notodolèe'
'my lips'	sedomàan(e')

Table 3: The control set, terms that were mixed at random into the first elicitation task. These are meant to provide tokens where tone is not predicted to appear: they do not appear on Krauss' wordlist above, nor were they glottalized in PA reconstructions. All were selected from the Koyukon Athabaskan Dictionary (Jones and Jetté 2000).

Control List			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
dleł	mountain	dleł tuh kk’o’eedoyh	He is walking around in the mountains
deł	blood	bugh deł hoolaanh	it is bloody
yeets	breath	beyeets neggudze	he is short-winded
telege	golden eagle		
kk’uh	fat	bekk’uh nekoh	it has much fat

Recruiting consultants for linguistic work on a language as endangered as is Lower Koyukon is challenging. Finding speakers is a matter of community connections, as the remaining speakers are elders, prized and guarded members of the community. Furthermore, a larger pool of speakers would eb more desirable for scientific reasons, but not possible to obtain when there are only a handful of speakers left. Thus we sought participation from any willing speakers of Lower Koyukon in Nulato, Alaska and did not select speakers based on age, gender, or other variables. One person was willing to participate as a consultant, along with a proficient facilitator and other helpers. The structure of the sessions was therefore different than anticipated, but having the facilitator present to assist the consultant in reading, translation, and bringing a comfortable atmosphere ensured that the data collection went smoothly and was fun for all involved.

The consultant was asked to perform a series of tasks in order to elicit target words that were expected to carry tone. On the first meeting, during preliminary data collection, the consultant

was asked to teach the researcher certain weather terms that were known to have contained a glottal stop in Proto-Athabaskan. This, however, was not a part of the official methodology, and was simply groundwork for the actual study.

Both the consultant and facilitator were first interviewed to get demographic information, including name, place of birth, family information, language abilities, et cetera. The first elicitation task was a game of bingo. The primary consultant, facilitator, and the researcher were given custom bingo cards containing squares filled with phrases from Table 1, as well as several sentences selected at random from the dictionary. Each participant was then asked to be the announcer for two rounds. A copy of each term on each square was put into a bowl, which the announcer draws from and speaks aloud. This task was designed to elicit tone in two ways: first, by having a speaker produce each word naturally, and second, by having the speaker teach their pronunciation to the researcher, as they drew bingo tokens during their rounds as announcer. Two different sets of bingo cards were used, one with words in isolation and one with words in phrases.

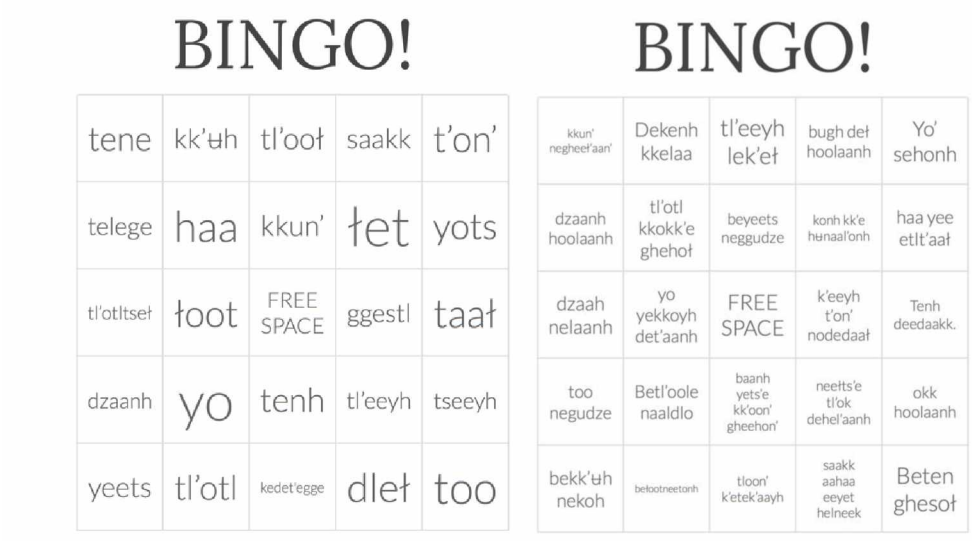

Figure 3: Sample bingo elicitation cards.

The second elicitation task involves having the participants read from the sentences in Table 2. This task was adapted specifically for the consultant, as she stated in the preliminary interviews that she was more comfortable reading or having text presented to her than she was producing it, especially when discussing dialect differences and metalinguistic information. Again, this task was framed as a learning opportunity for the researcher: the consultant was asked to teach the consultant how to pronounce these phrases, rather than simply reading them off of a page.[2]

Finally, the consultant was asked to read aloud from a simple story by Catherine Attla, Tsongguda 'Willow Grouse', obtained from the Alaska Native Language Archive (Attla 1983:31). Any morphemes in this story that contain stem-final glottals when reconstructed in PA would be predicted to carry tone. This task was meant to provide a pool of tokens in which tone may surface in predictable locations.[3]

3.2 Analytical Methods

In order to prepare the data for analysis, tokens were organized according to certain characteristics, such as whether or not the syllable was stressed, where in the word it occurred, and if it was spoken in isolation. Also separated were vowels beside an ejective or glottalized consonants and vowels not beside a glottalized consonant. This is because, as mentioned above, glottalization has phonation effects; in order to accurately measure phonation, glottalization must be controlled for.

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[2] The bingo task was intended to elicit maximally natural speech by providing an entertaining and productive elicitation session, as opposed to language work that can bore a consultant and produce non-natural lab speech.

[3] As is often the case in the field, the proposed methodology did not always work out as cleanly as it does on paper. All of the tasks were performed as a small group that included the researcher, the consultant, and an assistant/transcriber. While it was proposed that each participant play bingo as the announcer for two rounds, each round ended up taking so long that each person only played announcer once. In the final task, the story reading, it turned out that the transcriber had recently drafted a poem with the consultant, and we opted to substitute it for the Catherine Attla text.

The primary analysis was of the F_0 of the target vowels. F_0 is the acoustic correlate of pitch; it is expected to be markedly higher or lower in instances of high and low tone. F_0 measurements (in Hz) were taken at the 20%, 50%, and 80% marks, to account for the beginning, middle, and end of the vowel duration. Measures of shimmer and jitter were taken throughout the duration of the vowel, to account for phonation throughout the segment. Shimmer and jitter, measurements of voice quality, were taken to account for any changes in creak throughout the target segments.

In Leer and Kingston's accounts of tonogenesis, non-modal phonation, mainly creakiness, plays a significant role. They argue that coda glottal features often surface as creakiness on the preceding vowel or syllable, which in turn becomes low tone. Because other Dené languages follow this pattern, it is expected that Lower Koyukon will as well, should it be shown to still have tone. Creakiness, as a laryngeal function, can be measured; parameters often associated with creak are shimmer and jitter, based off of the F_0. Both are cycle-to-cycle measurements of stability in the F_0: shimmer is a measurement of the variability of the amplitudes of consecutive periods, while jitter is a measurement of the variability of the frequency of consecutive periods. Higher levels of shimmer and jitter are indicators of increased variability in amplitude and frequency of the F_0; exaggerated numbers indicate non-modal phonation. It is expected that, where tone is present in a target syllable adjacent to a glottal, that that vowel will show higher rates of variability. Where there is tone in a target syllable without an adjacent glottal, there may be evidence of variability. Finally, it is expected that syllables not predicted to show tone will have the lowest rates of shimmer and jitter.

Leer states that "PA constriction was a phonation type with associated tonal properties" (Leer 1999:59). As discussed earlier, this pairing of phonation and tone is a key piece of the puzzle that would explain the divide between high-tone and low-tone Athabaskan languages. It also

further implies that tone and phonation are inextricable, meaning that we would expect to find evidence of non-modal phonation where there is tone. In short, this study seeks to use these measures of phonation, shimmer and jitter, to provide some clarity to Leer's speculation on whether languages with tone retain aspects of non-modal phonation (Leer 1999:62).

4. Results

Data collection resulted in nine audio recordings over two days, totaling approximately 198 minutes. After transcription, there were 242 total tokens from the bingo task and 33 from the second word list task. The Catherine Attla/poetry reading task did not yield any usable data. This was partially due to discrepancies between the spelling conventions used in the story and those preferred by the consultant. Furthermore, while several recordings from written sources were obtained, including the Lord's Prayer and the Nulato high school graduation speech traditionally given by the elders, without transcriptions the researcher was unable to determine which syllables could be predicted to carry tone.

After analysis, the findings for this study were divided into two separate categories: the quantitative results that come from the tokens gathered during the bingo sessions, and the qualitative results that come from the pronunciation teaching task and notable tokens.

In order to prepare for quantitative analysis, all tokens from the bingo task— 242 total— were organized into a spreadsheet and assigned identification numbers. These tokens represent the target vowels from words on the primary and secondary word lists. They were then marked as being glottalized in proto-Athabaskan, control, or neither. Finally, each vowel was run through Praat's voice report tool, providing numbers for minimum, maximum, and mean pitch, number of pulses, and local shimmer and jitter.

Next, each token was measured for pitch contour. Measures of F_0 and amplitude were taken by hand at 'early' and 'late' points in each vowel's duration. Taking the measures by hand allowed for the researcher to tailor the measurement to each token while remaining consistent across the data set. 'Early' was defined as a point in the first third of the token duration, once F_2 became clear; 'late' is any point in the last third of the duration, before any late-vowel phonology. Finally,

the resulting pitch numbers were subtracted from one another, providing a positive contour outcome if the pitch of the vowel fell and a negative outcome if it rose.

Of the 242 bingo task tokens, only 139 were usable. This was generally due to the length of the vowels: as shimmer and jitter are fundamental measures for this study, and are taken as measurements over time, tokens that had less than twenty pulses were removed from the final token list. Tokens in which the word was whispered, interrupted, or that Praat was unable to accurately read on the same pitch settings as the others were also removed or skipped. The task one token list was then divided into three primary categories for comparison: PA-glottalized (69 tokens), controls (12 tokens), and neither (54 tokens). The PA-glottalized tokens were then further stratified into two categories: vowels near a glottal, and vowels not near a glottal. Figure 4 below is a visual representation of the data organization.

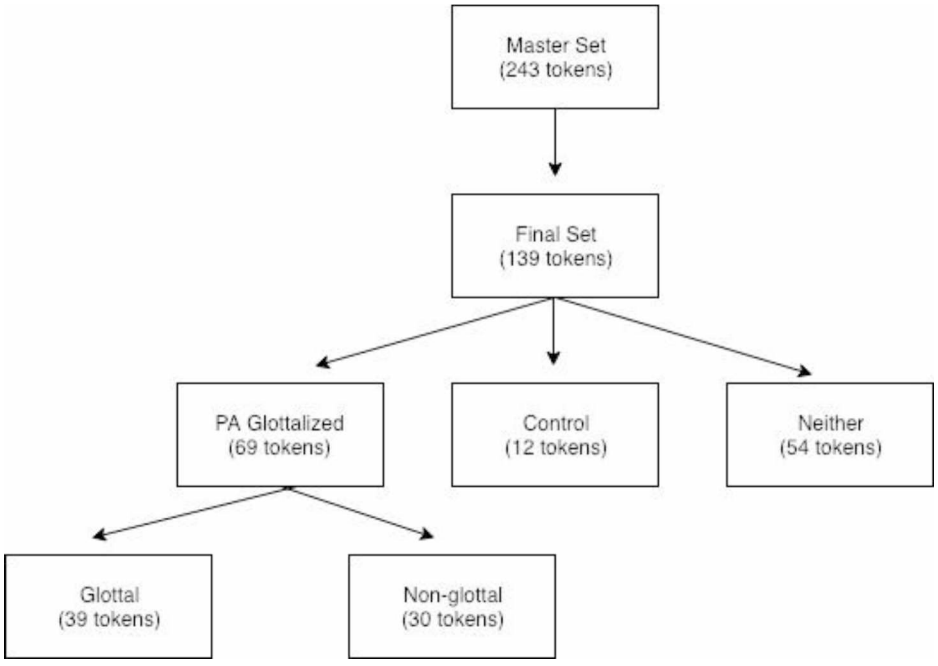

Figure 4: Visual representation of data organization

Once the data was organized, it was ready for the statistical analysis. A series of t-tests were conducted with JMP on the variables for mean pitch, pitch contour, shimmer, and jitter to determine if there were any significant differences among these data sets (SAS Institute 2013). The numbers shown in Table 4 are the raw values for the primary variables for the initial three sets, the PA glottalized, control, and neither:

Table 4: Variable values for task one tokens

	Task 1 PA Glott	**Task 1 Control**	**Task 1 Other**
Mean pitch (Hz)	157.631	165.952	169.754
Mean contour (Hz)	-4.809	1.608	0.919
Mean shimmer (local)	11.604	8.321	10.76
Mean jitter (local)	1.567	1.116	2.918

These raw numbers appear to indicate several trends: first, only the PA glottalized tokens showed a negative contour. That set also had the lowest mean pitch. However, across the board it does not appear that any of these token sets are significantly different.

Running these numbers through t-tests paints a different picture. Table 5 is a breakdown of every statistical test run on this data. In this table, 'PA' refers to tokens that were glottalized in Proto-Athabaskan, 'control' refers to control tokens, and 'other' refers to tokens that were neither glottalized in PA nor controls. These sets were all compared to one another for each of the four primary variables, mean pitch, contour, shimmer, and jitter.

Table 5: Summary of t-test results. Outcomes where the p-value was less than .05 are in bold.

Variable	Sets Tested	t Ratio	Prob > |t| (p value)
Mean F_0	PA vs. Control	-1.3896	0.1734
	PA vs. Other	-1.769	0.0798
	Control vs. Other	0.544	0.589
	PA Non-Glott vs. PA Glott	0.525	0.6011
Contour	PA vs. Control	-1.0569	0.2985
	PA vs. Other	-1.03268	0.3038
	Control vs. Other	-0.296	0.7695
	PA Non-Glott vs. PA Glott	-0.8096	0.4211
Shimmer	**PA vs. Control**	**4.647**	**<.0001**
	PA vs. Other	1.144	0.2548
	Control vs. Other	**3.391**	**0.0016**
	PA Non-Glott vs. PA Glott	-0.554	0.582
Jitter	**PA vs. Control**	**2.074**	**0.0476**
	PA vs. Other	-1.0389	0.3035
	Control vs. Other	1.399	0.1674
	PA Non-Glott vs. PA Glott	1.37	0.179

The statistical results displayed in Table 5 show that there is a negligible difference among all of the data sets for most variables. The only statistically significant differences are for measures of voice quality between the Proto-Athabaskan glottalized set and the control set.

5. Discussion

While the statistical results appear to show that, overall, most tonal differences are negligible, it is important to note that these numbers do not take into account several factors which may skew the data. Firstly, stress and intonation effects have not been taken into account for this first task. This portion of the study was intended to be a purely acoustic phonetic approach to Lower Koyukon tonal syllables, to explore any inherent vestigial tone in the syllables themselves. That is to say, the impacts of stress and intonation were not controlled for in the data presented above.

Secondly, the set of usable data is too small to produce completely accurate statistics. While the statistics can highlight important trends in the data, with only twelve control tokens it cannot be taken as law. Furthermore, only one consultant was available for this study; it may be the case that any conclusions drawn from the results are indicative of their linguistic behavior and do not reflect broader trends in Lower Koyukon.

These caveats aside, outcomes of the t-tests show that there is a statistically significant difference in voice quality between the Proto-Athabaskan glottalized set of tokens and the control set. Looking back at Table 5, we see that the PA set showed greater shimmer and jitter than the control set. As shimmer and jitter are indicators of creaky voice, this means that the PA set is, on the whole, creakier than the control set. However, there is no statistically significant difference in either mean pitch or pitch contour between the PA and control sets. Looking strictly at the numbers, it appears that the creak appearing in the PA set may be evidence of vestigial tone, realized today only in voice quality and not in pitch.

Krauss (1979:10) cites a possible reason why some Athabaskan languages trended towards low tone, while other trended towards high. He restates a simple possibility, first suggested by Leer (p.c.):

> The [± glottal] feature can easily be suprasegmentalized in a form which is still glottal but not tonal, and which then in some languages (Chipewyan-Hare) becomes high tone, and in others low (Sarcee-Kutchin-Navajo). Here we may also go back to Morice's (1902-033.528) remarkable reference to the raising of the voice "with a sort of constrained effort" in e.g. *khon'* "fire", *tze* "gum", "though many other monosyllables lack this distinguishing feature". Morice here has an amazing precursor to Leer's term "constricted" for the feature distinguishing the PA vowels that became high-toned in C-H and low in S-K-N (Krauss 1979:10).

The fact that the statistics for this study provide reasonable evidence that creak still has effect on stems that were glottalized in Proto-Athabaskan lends further credence to the relationship between voice quality and tone.

However, because of the low number of tokens, non-quantitative approaches to the data were also employed. There are several instances of clearly pronounced and intentional high tone throughout the study's recordings. Take, for example, token 233:

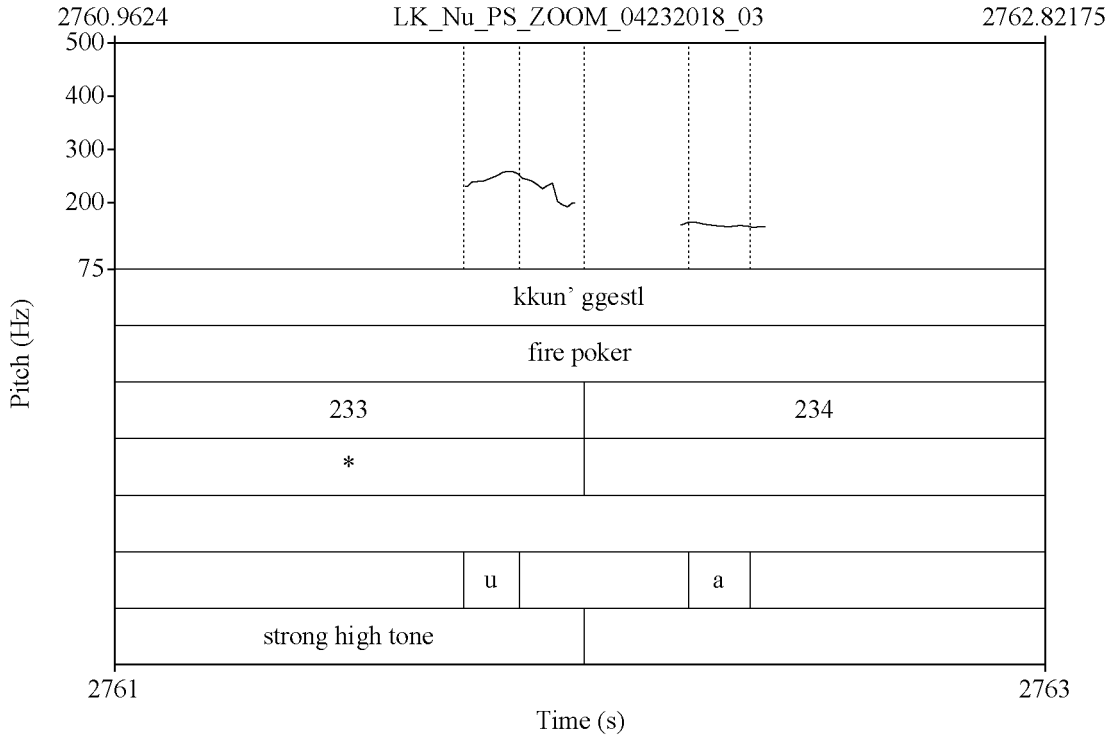

Figure 5: A pitch mapping of token 233

The pitch contour in Figure 5 is the consultant is saying *kkun' ggestł*, 'fire poker'[4]. Most interesting is that this is an example of two target words compounded together. Furthermore, both *kkun'* (fire) and *ggestł* (cane) are from the same tone-developing environment identified in Krauss (1979): both are constricted reduced-vowel stems, closed with sonorants. However, *kkun'* was, per the Koyukon Athabaskan Dictionary, glottalized in Proto-Athabaskan, while *ggestł* was not. There is a clear pitch spike in *kkun'*; the mean pitch is 241.13 Hz, while the mean pitch of *ggestł* is 163.44 Hz.

This is a clear-cut example of a high tone. However, whether this tone is due to inherent, vestigial tone on *kkun'*, if it is due to the voice quality effects of the glottalized sonorant closing the syllable, or if it is an intonational effect is unclear. Because of the presence of the glottal stop at the end of *kkun'*, if anything should carry a low tone, *kkun'* should. However, it does not appear

[4] IPA: /kʰʊnʔ kastɬ/

to. It could be that the high tone found is lexical, and could come from the default intonational contour of words spoken in isolation— accented high and lowering at the end of the phrase.

Further corroborating evidence that the tone found in Figure 5 above is a lexical property of the word can be found in the set of Proto-Athabaskan glottalized target words without glottalized consonants, for example token 50:

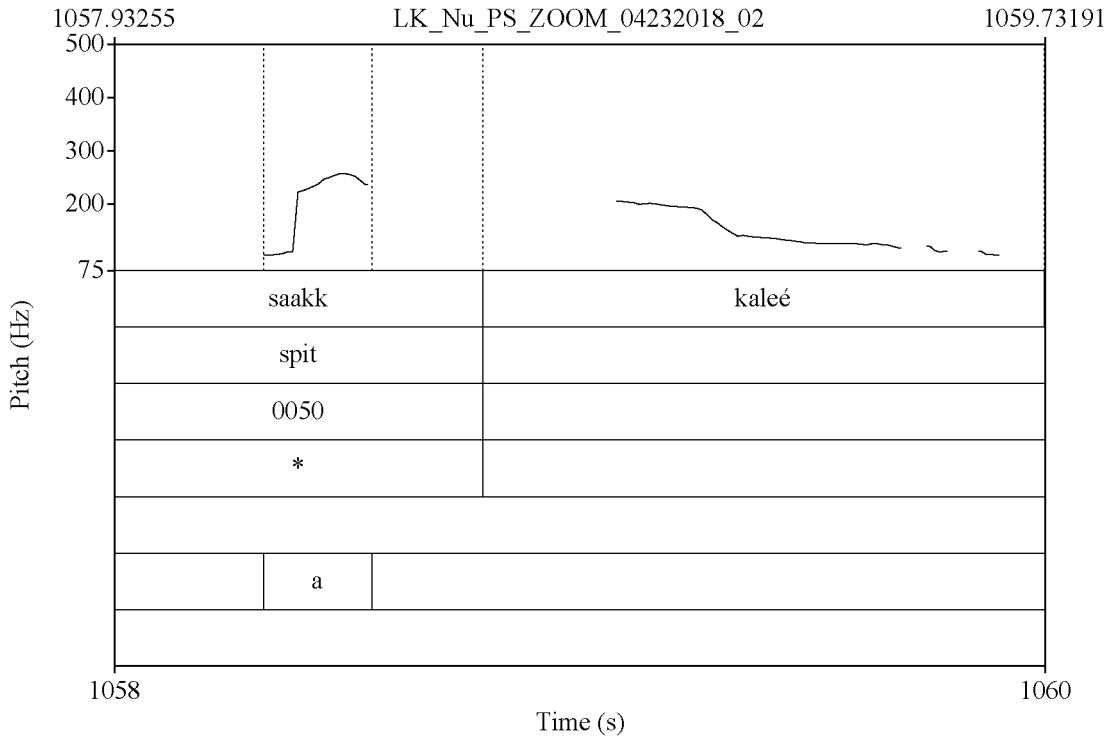

Figure 6: A pitch mapping of token 0050

Figure 6 is a pitch mapping of another instance of high tone. This time, the target word *saakk*, which, like *kkun'*, was glottalized in Proto-Athabaskan, contains no glottalized consonants today. Nevertheless, there is a clear high pitch on the vowel, which falls across the rest of the full phrase.

The examples given in Figures 5 & 6 clearly illustrate that high tone can present in cases where there both are and are not glottalized consonants present in the modern word. It is no

coincidence that both *kkun'* and *saakk* were glottalized in Proto-Athabaskan: these examples lend credence to the existence of lexical tone present today in Lower Koyukon.

More examples of high tone come from the second elicitation task. Here, the consultant was asked to teach the researcher certain words and phrases that, per Krauss, are known to contain tone (Jules & Jetté 2000). These examples definitely provide more evidence that the tone found in this study is high, relative to surrounding syllables. This portion of the data also illuminates potential effects of the co-articulation of stress and tone.

There were 33 total tokens from the second task. Many of the tokens produced by the consultant had to be put aside. This was either because the speech was interrupted or poor recording quality, the consultant's corrections to the word list circumvented the target syllable, or, in an effort to teach the researcher pronunciation, the speaker clearly overenunciated. Nearly all of the elicited terms displayed a high tone on the syllable predicted by Krauss to carry tone. The following data table shows all of the pitch measurements for all elicited words or phrases that had only one predicted tonal syllable.

The word list for the second elicitation task of this study is based on predictions that Krauss wrote in a forward to the Koyukon Athabaskan dictionary. In it, he states that Lower Koyukon tone "can be described at markedly low pitch on certain syllables, especially certain verb prefixes" (Jones and Jetté 2000:lvi). He marked the low pitch with a downward-pointed grave accent mark over the vowel. Any syllable marked with the acute was predicted by Krauss to carry a low tone.

Table 6: A breakdown of task two elicitation data, where each token has one syllable expected to carry tone. The "Predicted Pitch Contour" column describes the pitch for each syllable in the word as predicted by Krauss. Note that this contour only describes the potential lexical tones within each word, and not any suprasegmental interference from stress and intonation.

ID Number	Word	Translation	Predicted Pitch Contour	Preceding Syllable Pitch (Hz)	Tonal Syllable Pitch (Hz)	Following Syllable Pitch (Hz)
243	**táaleyo**	**he went**	L-M-M		**172.24**	**142.41**
244	**táaleyo**	**he went**	L-M-M		**182.81**	**107.382**
245	**notáaleyo**	**he went back**	M-L-M-M	**141.1**	**159.24**	**132.56**
246	**notáaleyo**	**he went back**	M-L-M-M	**133.97**	**143.2**	**132.4**
247	nótohoł	he'll go across	L-M-M		157.52	163.27
248	nótohoł	he'll go across	L-M-M		137.32	138.61
249	**nótohoł**	**he'll go across**	L-M-M		**126.96**	**126.9**
250	nótohoł	he'll go across	L-M-M		121.58	125.06
251	**nónotodoł**	**he'll go back across**	L-M-M-M	**157.46**	**205.15**	**102.87**
252	**nónotodoł**	**he'll go back across**	L-M-M-M	**132.34**	**169.76**	**117.89**
253	**nónotodoł**	**he'll go back across**	L-M-M-M	**129.79**	**151.77**	**119.29**
254	tógheeyo	he walked into the water	L-M-M		128.47	148.82
255	tógheeyo	he walked into the water	L-M-M		135.54	156.75
256	tógheeyo	he walked into the water	L-M-M		143.93	148.03
259	**yeyéeldo**	**he's sitting in it**	M-L-M	**172.65**	**202.54**	**125.69**
260	**yeyéeldo**	**he's sitting in it**	M-L-M	**184.94**	**197.83**	**126.29**
261	meyée leedo	sit in it	M-L-M-M	199.79	199.83	205.13
262	meyée leedo	sit in it	M-L-M-M	164.91	173.87	200.93
266	seyél tohol	he'll go with me	M-L-M-M	194.54	192.66	172.89
267	seyél tohol	he'll go with me	M-L-M-M	182.58	170.79	152.74
280	**nóghuy**	**frog**	L-M		**147.79**	**135.82**
281	**nóghuy**	**frog**	L-M		**155.94**	**142.18**
282	**nóghuy**	**frog**	L-M		**165.64**	**129.28**
288	sedomáan	my lips	M-M-L	163.47	145.67	
289	sedomáan	my lips	M-M-L	139.93	135.63	
290	sedomáan	my lips	M-M-L	139.58	131.8	

In this table, the 'tonal syllable pitch' column represents a measurement of mean pitch (in Hz.) across the duration of the vowel of the syllable that is predicted to have tone. That syllable is marked with a grave over the corresponding vowel in the 'word' column.

Despite Krauss' predictions of low tone on the predicted syllables, half of the tokens in Table 6— 13 out of 26— have a tonal syllable with a higher mean pitch than the syllables around it. These are in bold. There are many very clear examples of high tone in this set. For example, token 243:

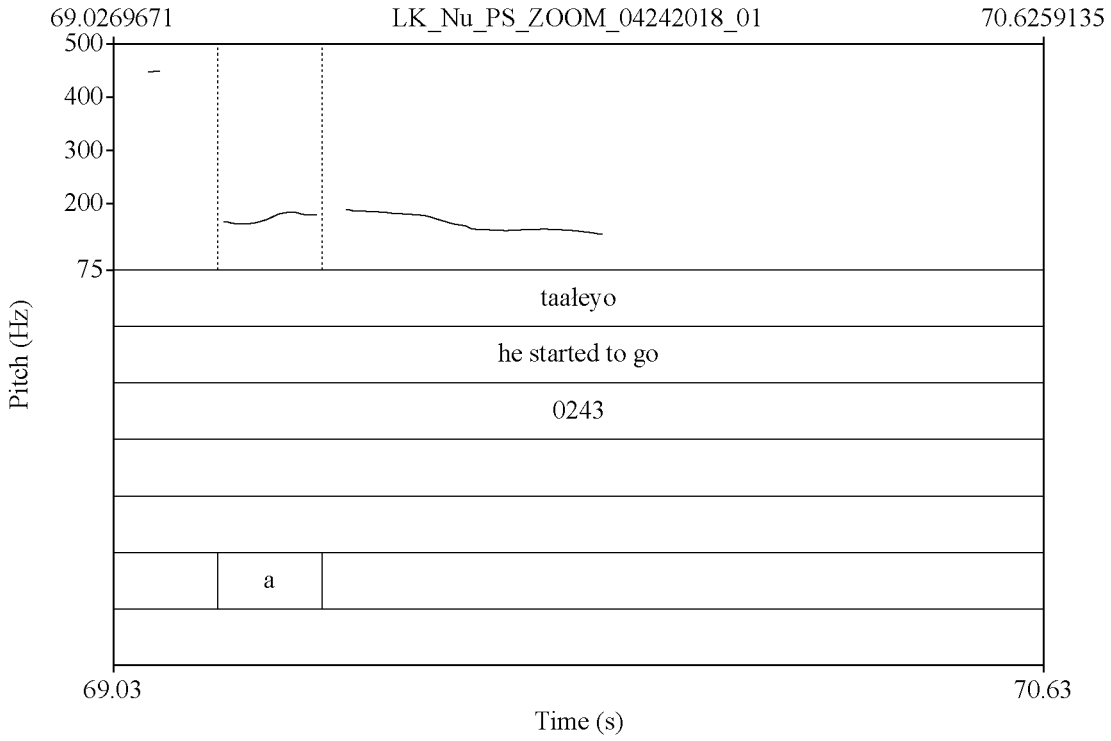

Figure 7: A pitch mapping of token 243

Tone was predicted to appear on the [a] vowel. The mean pitch of the tonal syllable, taken throughout the duration of its [a] vowel, was 172.24 Hz, while the following syllable had a mean pitch of only 142.41 Hz. This may be evidence that there both is tone, and that said tone is high. Others tokens, namely numbers 266 and 267, do not have a lower pitch on the syllable preceding the tonal one, but do fall in pitch after the tonal syllable. This is not surprising, as tone is a

suprasegmental feature that is likely to bleed into neighboring syllables that are not marked for tone. However, the fall in pitch after a tonal syllable, while it may be evidence for tone, may also be the effect of natural intonational contours in an utterance, starting high and ending low.

Finally, there is the group of tokens (numbers 254-256, 262, and 288-290) where a non-tonal syllable carries a higher pitch than the tonal syllable. These are potentially examples of stress co-articulating with high tone, attracting it to a different syllable. It is also possible that, as Krauss predicted, the first syllable (with a lower pitch) is low tone surfacing, and that the higher pitch recorded in the second syllable is not high tone, but rather a raised pitch from stress, independent from the lexical tone. In tokens 254-256, the tone is predicted from Krauss to fall on the first syllable of the word *togheeyo* 'he walked into the water' (Jones and Jetté 2000, lvii). However, the consultant stresses the second syllable. As Lower Koyukon tone is vestigial, it would make sense that it is overshadowed by such grammatically relevant prosodic processes. The same is true of token 262, wherein the consultant placed heavy stress on the syllable following the predicted tonal syllable, and of tokens 288-290, where stress came on the syllable prior. This is consistent with the pattern that tone is attracted to stress; however, there is not enough data in this study to make that claim. It is also not inconsistent with Krauss' predictions, as Krauss predicted low tone on the first syllable for tokens 254-256. They simply do not match the rest of the findings; if they did, the first syllable would show evidence of a high tone. Instead, the first syllable was pronounced lower than the second. The contour of these tokens does not follow the pattern of tone established by the rest of the data.

Tokens 251-253 are special cases in which high tone was clearly enunciated several times, just on the second syllable rather than the first (as predicted). It is likely the case here that the speaker chose to put the high tone on the second syllable, rather than the anticipated first. No

matter the case, high tone is still clearly visible. This is illustrated in the pitch mapping of token 251 below:

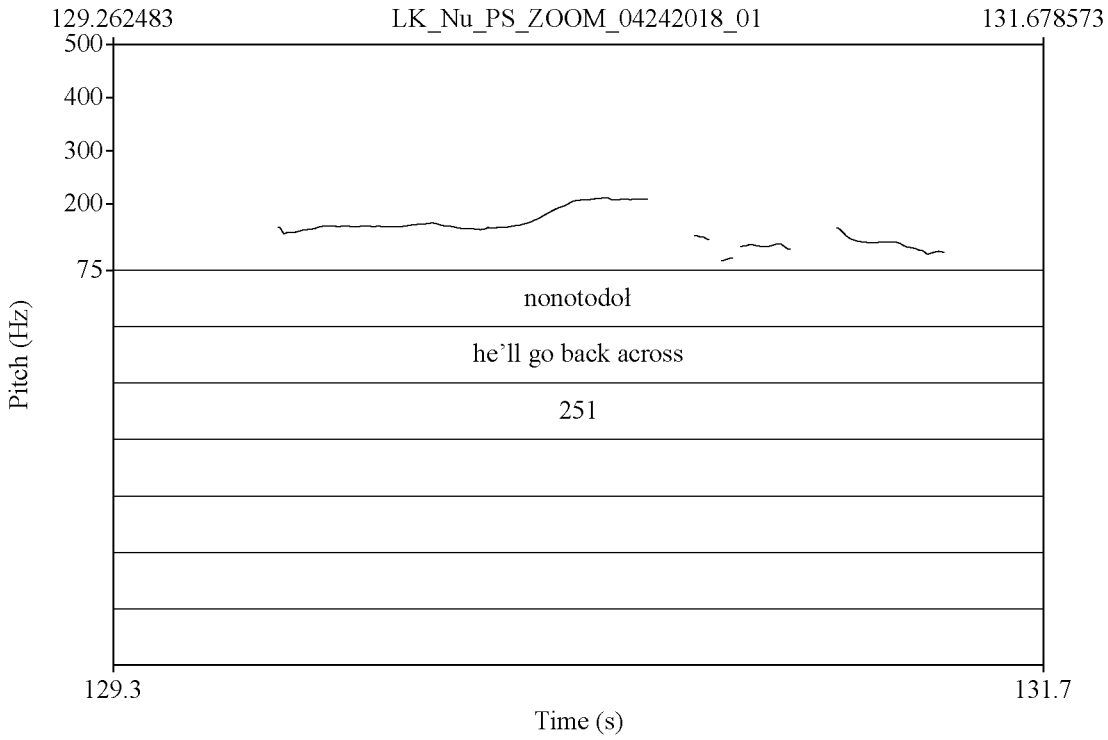

Figure 8: A pitch mapping of token 251

For Token 251-253, because of how distinct the high tone on the second syllable is, the second syllable is treated as the tonal syllable in the Table 7.

There are also examples of task two where there were more than one syllable expected to carry tone. Five of these were produced; their data can be found in Table 7 below.

Table 7: A breakdown of task two elicitation data, where each token has two syllables expected to carry tone

ID Number	Word	Translation	Predicted Pitch Contour	Tonal Syllable 1 Pitch (Hz)	Tonal Syllable 2 Pitch (Hz)	Following Syllable Pitch (Hz)
264	seyél táalyo	he went with me	M-L L-M	174.7	168.67	123.5
274	ya ga héts'én tohoł	he'll go there	M M L-L M-M	132.15	149.26	124.12
277	go héts'én' hadee tohoł	he'll go from there	M L-L M-M M-M	173.58	143.007	163.05
286	yootokkáadée'	will he buy it	M-M-L-L	194.58	139.82	N/A
287	yootokkáadée'	will he buy it	M-M-L-L	135.79	119.51	N/A

In these cases, both syllables expected to carry tone were measured for mean pitch, as well as the following syllable. Both tokens 264 and 274 follow previously discussed trends of high pitch on tonal syllables. Tokens 277, 286, and 287, however, have a glottal in the coda positions of the second tonal syllable. It is possible that this coda glottal is introducing synchronic phonation effects— creak— that drive the pitch of the preceding vowel down. This follows in Kingston (2005)'s description of high- and low-marked tone development: that creak carries with it a relatively low fundamental frequency. This is potentially an area for further study.

This study has shown that tone does appear to have an inextricable relationship with phonation, as predicted in Leer (1999). That this tone is high comes as a surprise. It was predicted, based on Krauss' accounts given in Jones and Jetté (2000), that if tone were found in Lower Koyukon today, it would be low. There are several reasons why this study's consultant may have produced different tones than those attested in previous work. It may be possible that previous consultants did produce a low tone, and due to any number of factors, including a lifetime of language contact, the consultant for this study produced a high tone.

Kingston offers insight into this question. He offers the following on the development of low- and high-marked tone languages:

> It has often been observed that post-vocalic glottal stop induces or varies freely in some languages with creaky voice…in other cases, glottal stop induces a tense voice quality on neighboring vowels. Tense voice differs from creak in having a higher fundamental frequency. In both voice qualities, the closed phase of the glottal cycle is longer relative to the open phase than in other voice qualities because of medial compression of the folds (Laver 1980: 122-26, 141-49). The principal acoustic result of lengthening the closed phase in the glottal cycle is to tilt the spectrum up: there will be more energy at high frequencies with tense and creak voice than during modal voice…the two voice qualities which derive from glottal stop…tense and creaky voice, are similar then in spectral properties but quite different in fundamental frequency: tense being high and creaky low.
>
> What became the low-marked Athabaskan languages could have selected the creaky voice quality with its low fundamental frequency as the realization of constriction, while those that became high-marked selected the high frequency, tense variant (Kingston 1985:27-28).

Modern-day Koyukon's tone is dismissed as vestigial or nonexistent in Leer (1999) and Krauss & Golla (1991), as can be seen in Figure 2. However, there is a possibility that different dialects of Koyukon— modern-day Lower, Central, and Upper— could have developed towards realizing constriction as tense, while others either realized constriction as creak or failed to realize it at all. This would result in one dialect developing high tone, while others did not. As creak and tense look similar, further study is required to determine if the phonation type shown to be statistically

significant in these results is creak or tension. There is nonetheless the possibility that the high tone seen in the data for this study is a result of linguistic behaviors unique to the consultant.

The overarching purpose of this study was to search for tone in Lower Koyukon; it is not a full description of that tone. This study corroborates previous proposals of the existence of tone in Lower Koyukon; far more extensive studies must be done to verify the results discussed here. It remains to be established whether the results of this study are indicators of dialect-wide trends, or if they are unique to the consultant. Moreover, neither stress nor intonation were controlled for in this study. While the second elicitation task did involve full phrases and sentences (Table 2), these were selected because Krauss, in his foreword to the Koyukon Athabaskan Dictionary, predicted that they would have tone. They were not designed for an intonation or stress study, and their environments are too variable to produce valid or cohesive observations on the co-articulation of tone, intonation, and stress.

6. Conclusion

The Athabaskan language family is very well-known for its tonal languages, of which there are three groups: those with high tone, those with low tone, and those with vestigial or nonexistent tone. Lower Koyukon is the only dialect of the language that has been attested to have any kind of tone, although it is widely agreed that if it does still exist, it is vestigial (Leer 1999, Krauss 1979, Krauss & Golla 1991). This study addressed three primary objectives: a) to determine the how low tone is produced in Lower Koyukon with respect to pitch; b) to examine the interactions between low tone and pitch-altering phenomena, such as stress; and c) to determine the realization of creaky phonation during low tone production. All of these make up the greater overall goal of providing evidence for the continued existence of tone in Lower Koyukon today.

In order to elicit the data for this study, three tasks were prepared. Two of them produced usable data: first, the consultant played a game of bingo in which the squares each contained either a target or a control word. Tokens were extracted from periods in which the consultant was announcing the bingo draw. Second, the consultant was asked to teach the researcher how to pronounce a series of words and phrases, all of which were expected to show evidence of tone. While there are many examples that show that Lower Koyukon does still have vestiges of tone, the statistics show that the only significant difference between the set of tokens that was glottalized in Proto-Athabaskan and the control group is in phonation.

This work leads to several open avenues for future research. First is further studies on the effects of co-articulation on tone. While there is some evidence given here to suggest that stress, a salient feature in modern Lower Koyukon, supercedes vestigial tone, a study that controls for stress and intonation would provide far more insight. Furthermore, as the number of both consultants

and tokens for this study are low, reproducing this work with a wider swath of consultants is vital to substantiate any claims about the nature of Lower Koyukon tone made here.

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Appendix A

These are the reworked primary and secondary word lists, edited after the consultant's recommendations. All changed words are in bold. Note that these changes may not be a comprehensive list of the differences between the Central and Lower dialects in this word list.

Category 1: Non-constricted full vowel stems, open and sonorant-closed			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
Sky	**yo yeet'**	the northern lights are shining	yo **yeet'** yekkoyh det'aanh
Water	too	the water is shallow	too negudze
Sun	ghe'ole		
Grease	**hhaa**	I am frying it in grease	**hhaa** yee **atlt'aał**
Day	dzaanh	It is day	dzaanh hoolaanh
Rain	konh, konh too	It looks like rain	konh kk'e hʉnaal'onh
*Mosquito	tl'eeyh	A swarm of mosquitos came out.	tl'eeyh lek'eł

Category 2: Non-constricted full-vowel stems closed with plain obstruent			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
*Ochre	tseeyh		

*Sand	łaats		
Coat	**da-aak**		
Rope	**tł'ooł**	His rope is there	**Metł'oołe oyt** naaldlo

Category 3: Non-constricted full-vowel stems closed with glottalized obstruent			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
*Moss, scum, algae	**tł'otł**	He is walking on the moss	**tł'otł kkokk'a ghahoł**
*Scab	łoot	It is covered with a scab, it is scabbed over	bełootneetonh
*Diaper moss, cradle	**tł'otłtseł**		
*Spit	saakk	he rubbed [the wound] with spit	saakk aahaa eeyet **halneek**

Category 4: Non-constricted reduced-vowel stems: closed with sonorant vs. closed with obstruent			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
Ice	tenh	The ice is thick.	Tenh deedaakk.
Stick	dekenh	There are no trees.	Dekenh kkelaa
Trail	**tenh**	I'm walking on his trail	**Meten ghasoł**

Smoke	łet	Smoke is coming out of there	**Hołetghee-o**

Category 5: Constricted full-vowel stems: open			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
Beaver	kedet'egge		
Louse	yo’	I am lousy (lice are eating me)	Yo’ sehonh
Arrow/**Gun**	**kk’uh’**		

Category 6: Constricted full vowel sonorant-closed			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
*Leaf	t’on’	Birch leaves are falling	**k’aayh** t’on’ nodedaał
*Roe	**kk’oonh**	His mother ate fish eggs	baanh yets’e **kk’oonh** gheehon’

Category 7: Constricted full-vowel stems: closed with obstruents			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
Mat	taał		

Category 8: Constricted full-vowel stems: closed with obstruents			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)

*Pitch	dzaah	It is pitch (soft, malleable)	dzaah nelaanh
*Fog	okk	It is foggy	okk hoolaanh
*Dish	**tł'ok**	They take turns giving each other a dish of food	neełts'e **tł'ok** dehel'aanh
Charcoal	t'aas	it [wood] is covered in charcoal (and not burning well)	baat'aas'ooghedenaadlegheł
*Knot	yots	I snared it	mek'elesyots

Category 9: Constricted reduced-vowel stems: closed with sonorants CvC'			
Term (ENG)	Term (LK)	Phrase (ENG)	Phrase (LK)
*Star	**tloonh**	there are shooting stars	**tloonh k'eteldz'eeyh**
*Handle, bow	ten'	it has a handle	**meten'** hoolaanh
*Fire	kkun'	he saw a fire, a falling star	kkun' negheeł'aan'
Cane	**ggastł**	fire poker	kkun' **ggastł**

Page lvi, lvii Koyukon dictionary	
Term (ENG)	Term (LK)
‘he went’	tàałeyo
'he went back'	notàałeyo
'he'll go across'	nòtohoł
'he'll go back across'	nònotodoł
'he went back across'	nònotàałeyo
'he walked into the water'	tògheeyo
‘he started to walk into the water’	tòtàalyo
'he's sitting in it'	yeyèeldo
'sit in it'	meyèe leedo
'he went with me'	**seyèł** tàalyo
'he'll go with me'	**seyèł tohoł**
'he'll walk with the aid of it'	**ggastł ye(e)ł tohoł**
'he'll start off with the aid of it'	**yahaa tohoł**
'he'll go there',	**yaga hots’en tohoł**
'he started off there',	**go hots’en hadeeyo**
'he'll go from there'	**go hots’en hadee tohoł**
'he started off from there'	**yege hots’en hadeeyo**
'frog’	**nòghoy**
'fox'	**kaagholggʉy**
‘black fox’	delzen

‘lynx’	**kaazen**
'will he buy it?'	yootokkàadèe'
'will he go back?'	**naan go no todok ghee’**
'my lips'	**sedomàan**

Appendix B

This section contains reference material for non-Koyukon speakers to read the Koyukon words discussed here. These materials are composed of an IPA list for both consonants and vowels and a comparison of their IPA forms with their most common orthographic forms (Tuttle 2018).

IPA	Koyukon Orthography
ɑ	o
æ	aa
i	ee
ɔ	o
u	oo
ʊ	~~u~~
ɛ	e
ə	i
p	b
t	d
c	g
k	gg
ʔ	’
t^h	t
c^h	k
k^h	kk
t’	t’
c’	k’
k’	kk’
q’	
ts	dz
tʃ	
tɬ	dl
ts^h	ts
$tʃ^h$	
ts’	ts’
tʃ’	
tʂ’	

tɬ’	tl’
s	s
ʃ	
ɬ	ɬ
x ~ χ	h
h	h
z	z
ʒ	
ʐ	
j	y
l	l
ɣ ~ ʁ	gh
m	m
n	n