Plosive reduction in South Baffin Inuktitut [*]

Matthew Schuurman
Université du Québec à Montréal

This paper presents novel findings on the acoustic properties of voiceless plosives in South Baffin Inuktitut. A known property of word-final plosives is that speakers appear to 'drop' these plosives (Allen 1996 a.o.). In this preliminary study, I investigate whether these word-final plosives are completely dropped or significantly reduced, with the result being that they are unreleased. Additionally, novel findings for Voice Onset Time (VOT) for these four plosives are presented. The paper is structured as follows. Section 1 presents general background information on South Baffin Inuktitut and an overview of the phonetic inventory. Section 2 details the specific research questions of the pilot study, while section 3 outlines the methodology used. Section 4 presents the findings of the study. Section 5 concludes.

1. Background

South Baffin Inuktitut (*South Qikiqtaaluk*) is an Inuktitut dialect spoken in the southern part of Baffin Island in Nunavut. Inuktitut is part of a larger Inuit language dialect continuum that is spoken across northern North America, from Alaska all the way to Greenland. South Baffin belongs to the Baffin dialect of Eastern Canadian Inuktitut. This is illustrated in Figure 1.
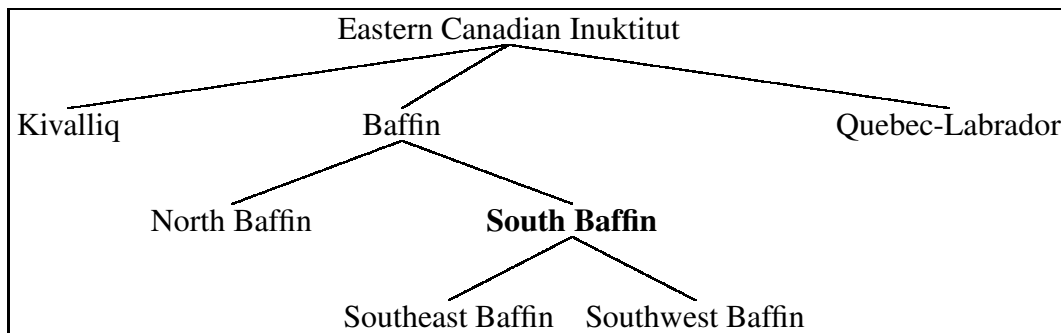

Figure 1: Inuktitut dialects (Dorais 2003: Figure 1)

While South Baffin consists of two sub-dialects, Southeast and Southwest, for the purposes of this study, it is sufficient to analyze them as one larger Inuktitut dialect. The

major difference between these two subdialects is the realization of **ɬ** which is realized as **t** in Southeast Baffin and **s** in Southwest Baffin in speech form (Dorais 2003 p.93). There has been no reported perceptual difference in the realization of plosives between these two subdialects. As of 1991, 90% of the population of South Baffin (4235 out of 4710 speakers) still speak the language.

The starting start point for this paper is the observation that Inuktitut has received relatively little attention from phoneticians to date, as is generally the case for Indigenous languages in Canada. As a result, while this paper does involve some hypothesis testing, as typically occurs in phonetic papers, this paper also makes a systematic generalization that produces limited findings which may not generalizable. However, this paper provides additional information that we can use to examine how spoken languages are produced and used.

1.1 Phonological Inventory and Prosody

In South Baffin Inuktitut, the phonological inventory involves fifteen consonants and three vowels. The vowels are /i/, /a/, and /u/, all of which have a long and short versions. The consonants can be roughly categorized as shown in Table 1, where both the IPA symbol and the Inuktitut orthography are presented.

	Labial	Coronal	Palatal	Velar	Uvular
Voiceless plosive	/p/ 'p'	/t/ 't'		/k/ 'k'	/q/ 'q'
Voiceless fricative		/s/ 's'			
Voiced fricative	/v/ 'v'	/l/ 'l'	/j/ 'j'	/ɣ/ 'g'	/ʁ/ 'r'
Nasal	/m/ 'm'	/n/ 'n'		/ŋ/ 'ng'	

Table 1: South Baffin Dialect: Consonant phoneme chart

Baffin Inuktitut differs from other dialects in that it does not have /b/, the voiced counterpart of the voiceless bilabial plosive, /p/. There are only four plosives in the language, bilabial /p/, coronal /t/, velar /k/, and uvular /q/. Each of these is voiceless without any voiced counterpart. The four plosives can appear word initially, word-medial, or word-final. However, the majority of word-final consonants are either /t/, /k/, or /q/, as the only case of word-final /p/ is in the ergative singular marker *-up*, as in (1).

(1) Jaani-up
     John-ERG.SG

There is a large tendency for speakers to not pronounce word-final plosives in discourse contexts. This is surprising as it permits the possibility of ambiguity since there are grammatical distinctions indicated by the final plosive. In Inuktitut, dual nouns are denoted by a word-final /k/, while plural nouns are denoted with /t/, as can be seen in (2) and (3).

(2) a. qarasaujaralaaq   b. qarasaujaralaak
         *laptop (sg)   *laptops (dual, 2)

(3) a. uqaalautiralaaq   b. uqaalautiralaaq
         *cellphone (sg)   *cellphones (plural, 3+)

2. Research Questions

There are two research questions for this study. First, are the unpronounced word-final stops in South Baffin Inuktitut 'dropped', that is phonetically deleted or, rather are they articulated but simply unreleased, that is, phonetically reduced? Second, what are the phonetic properties of the four stops: /p/, /t/, /k/, /q/, given that there is lack of information in the literature?

However, in order to answer the first question, it is first necessary to define what is meant by 'unreleased'. Previous research by Henderson and Repp (1982) outlines 5 stages of the released-unreleased continuum.

- *Unreleased:* there is no burst but the stop is maintained, as seen in stops with delayed release, such as stops followed by other stops.
- *Silently released:* there is no release in acoustic record.
- *Inaudibly released:* there is a visible release in the signal, but it is not easily detectable by ear.
- *Weakly released:* the burst is detectable by ear, but not as much as in the strongly released.
- *Strongly released:* the burst is clearly detectable followed by voicing or aspiration.

In other words, plosives were classified as released when they had an auditory detectable burst and it was manifested as the sudden rise of energy visible as acoustic transients in waveform and spectrogram. Any other plosive missing these two properties were classified as unreleased.

For this study, I use Henderson and Repp's characteristics for released stops, however, the definition of what is considered an unreleased plosive is modified. Given that the research question focuses on whether a plosive is dropped, or phonetically present, it is not sufficient to simply have a lack of a release in the acoustic record. Rather, there must also be articulatory cues indicating movement of the articulators towards a specific place of articulation for a particular plosive. That is, if a speaker says a word that ends in a /k/ and doesn't pronounce the word-final 'k', the plosive can only be considered unreleased if there are articulatory cues that indicate that the speaker is pronouncing an unreleased /k/. If there are no articulatory cues, then the plosive cannot be treated as unreleased.

Based on this definition of unreleased, I propose the hypothesis that the unpronounced word-final plosives are unreleased, and do not show evidence of a burst, but demonstrate evidence of articulatory movement for the respective plosive.

3. Data Collection

The data for this pilot study comes from an online corpus, tusaalanga.ca. There are two elements to the data, words spoken in isolation and dialogues. The words in isolation comes from a list of dictionary words spoken by a female speaker of the South Baffin dialect. Each dictionary entry was spoken in isolation and repeated once. The dialogues are between a different female speaker and a male speaker of the dialect. These dialogues were presented in written Inuktitut with an English gloss.

   In order for a word to be considered for analysis, there had to be one of the four plosives in either a word-medial or word-final position. In addition, the word-medial plosive had to be in an intervocalic position, while the word-final stop had to be preceded by a vowel. These requirements were necessary to ensure that: (i) there would be VOT in the case of the word-medial contexts, and (ii), the formant transitions between the preceding vowel and the stop would be present for both word-medial and word-final. Each token of the four stops occurred after either /i/, /a/, /u/, or /iː/, /aː/, /uː/. Any stop that was a part of a consonant cluster was not considered for analysis. In the dialogues, only plosives that were both word-final and phrase-final were considered, in order to avoid interactions between the final plosive and the vowel or consolation of the following word.

   For the dictionary entries, a total list of 197 words were included, each with two repetitions, for a total of 394 words. For the dialogues, there were a total of 100 words. All the plosive tokens from the dialogues were word-final and are found in words that are phrase final. This was done to ensure that there was no effect from a following word. The precise distribution of each phoneme can be seen in Table 2 and Table 3.

Plosive	Words in isolation				Words from dialogues			
	/a_/	/i_/	/u_/	**Total**	/a_/	/i_/	/u_/	**Total**
/t/	22	42	42	**106**	8	23	9	**40**
/k/	34	72	40	**146**	–	13	6	**26**
/q/	126	58	150	**334**	4	–	22	**19**

Table 2: Word-final plosive distribution from database

Plosive	Words in isolation			
	/a_/	/i_/	/u_/	**Total**
/p/	20	16	10	**46**
/t/	38	20	44	**82**
/k/	28	24	20	**72**
/q/	18	14	6	**38**

Table 3: Word-medial plosive distribution

3.1 Methodology

Each recording was annotated using Praat. The formants and the time measurements were automatically detected and extracted using a Praat script. The script took measurements of F1, F2, and F3 for each vowel preceding the target stop at 50% and 90% of the vowel's duration. The initial time and end time of both the preceding vowel and the target plosive were also extracted. The data was then hand corrected for any errors, which eliminated nine plosive tokens. Formant detection was done using Praat's implementation of the Burg algorithm for calculating LPC coefficients. The settings used were the default settings (0.0 second time step, a maximum of 5 formants, window length of 0.025 seconds, and pre-emphasis from 50 Hz), except for the maximum formant frequency, which was specified to be 5500 Hz for the two female speakers and 5000 Hz for the male speaker.

An example of an analyzed word with two plosive tokens, one medial, one final can be seen in Figure 2. In this example, the word *aput* 'snow' was analyzed, with a medial /p/ and final /t/. The preceding vowel token for each stop was segmented using an interval tier. Each stop was also segmented and coded using the following labelling system *plosive_repetition_pre-vowel_post-vowel_position_syllable*. The plosive was then annotated using a point tier with a boundary at the initial moment of the burst and the aspiration peak. For those tokens where there is no audible moment of burst, there was no point tier markers indicated, only the initial and final boundary on the interval tier annotating the preceding vowel and the plosive token.
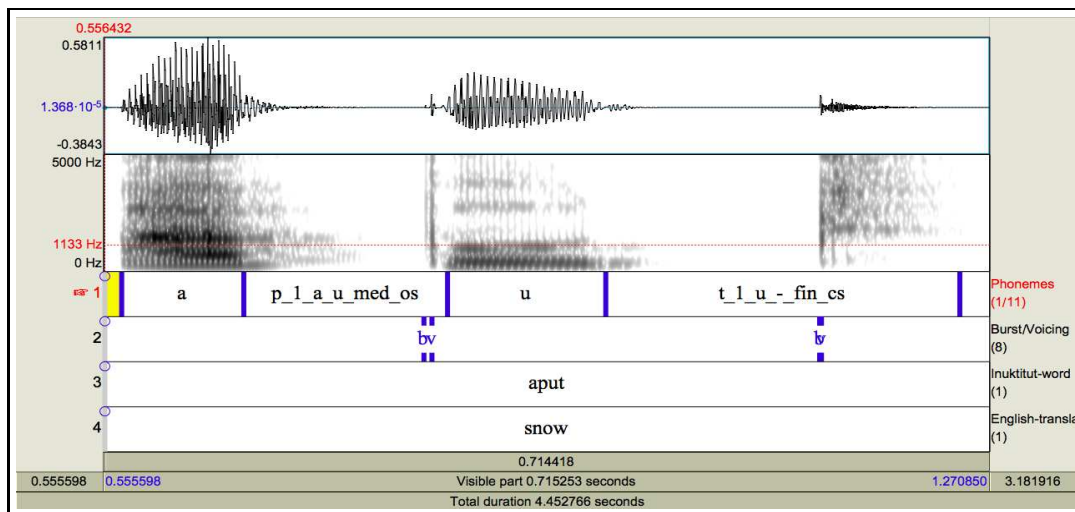

Figure 2: Praat annotation of 'aput'

4. Analysis

4.1 Voice Onset Time

The first analysis of this paper considers the voice onset time (VOT) of the four plosives. VOT is a measurement of the length of time from the release of the plosive to the onset

of voicing. It is well established that there is a tendency for VOT to be longer when the closure for a plosive is made further back in the vocal tract (Fisher-Jorgensen 1954; Peter & Lehiste 1960; Cho & Ladefoged 1999). The general hypothesis is then that if the length of VOT is simply due to the distance from the anterior to the posterior of the vocal tract, then the VOT for a labial plosive should be the shortest, while the VOT for a uvular plosive should be longest.

For this investigation, only word-medial intervocalic plosives were analyzed, to ensure there was vowel following the plosive to have the onset of voicing. The VOT for each token was measured from the burst of the consonant to the onset of the first formant of the following vowel. The total VOT for each token was then grouped according to the preceding vowel and the plosive. The results can be seen in Table 4.
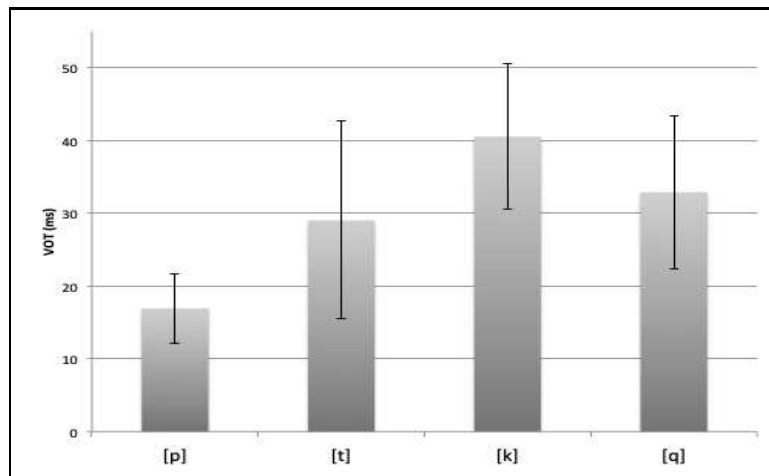

Table 4: Mean voice onset time (ms) by categories of plosive. (Data averaged across speakers. Error bars refers to standard deviation.)

For all four plosives, there is a positive VOT value, indicating the presence of aspiration. There is also an increase in VOT from /p/ to /t/ to /k/, which is expected given that this is representative of the distance from anterior to the posterior of the vocal tract. However, the VOT of the uvular /q/ (32.88) is lower than the VOT of the velar /k/ (40.53), despite being further posterior, and therefore a longer distance. That the uvular VOT is shorter than the velar VOT seems at odds with the tendency that the further forward a plosive is made, the shorter the VOT. However, Cho & Ladefoged (1999) point out that there is a great deal of variation among VOTs in different languages. Thus, while some variations among VOT values can be attributed using mechanical areo-dynamic effects associated with different places of articulation, others cannot be explained in this way. What is left then is variation that results from the particular choices made by individual languages. In summary, Inuktitut follows other languages in regards to its VOT plosive pattern.

4.2 Word-final plosives

The final section of the analysis concerns word-final plosives. As stated in §1, there is a strong tendency for speakers to 'drop' word-final plosives in discourse contexts. This tendency is significantly robust, for example, out of the 100 discourse words analyzed for this study, there were only two instances where a word-final plosive was pronounced. An example of the only minimal pair found in the online corpus can be seen below in Figure 6. The upper spectrogram contains the word *kikiak* with a dropped word final plosive, while the lower spectrogram contains the pronounced counterpart.
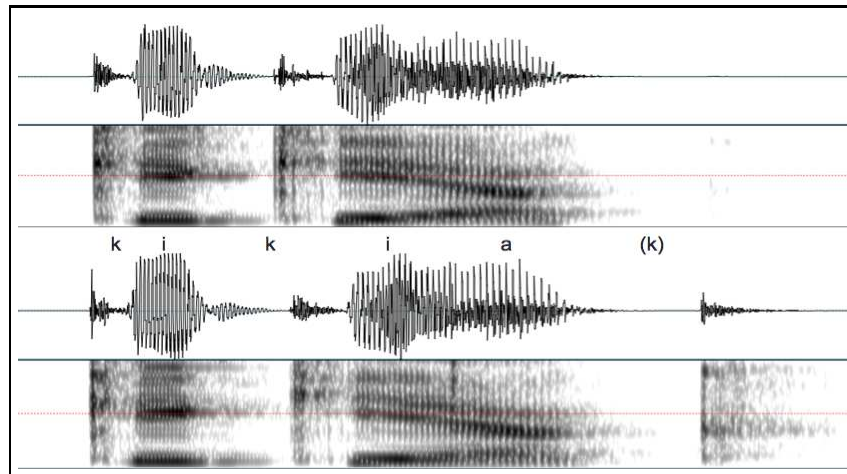
Figure 3: Example of dropped vs. released word-final plosive *kikiak* 'nail (hardware)'

The hypothesis I have adopted is that the 'dropped' plosives are actually unreleased, meaning that there is articulatory movement towards a plosive, however, there is no burst, resulting in the perception that the plosive is unpronounced. To determine whether there was evidence of articulatory movement, the values of the preceding vowels at 90% duration were compared to the preceding vowel at 90% for /t/, /k/, /q/, in both the pronounced word-final contexts and for the 'dropped' contexts. If the values for the 'dropped' plosives matches that of the pronounced plosives, then this is taken as evidence that there is articulatory movement. For example, if the values of the 'dropped' /t/ matches that of the pronounced /t/, and not those of the /k/ or /q/, then this is evidence that the articulators have moved into position to pronounce /t/, but as there is no burst, the result is an unreleased /t/. Conversely, if the vowel values demonstrate a lack of articulatory movement, then the expectation is that the values for all vowels preceding an unpronounced /t/, /k/, /q/ at 90% should match that of the particular preceding vowel, and not those of the pronounced counterpart plosive. It should be noted that there were no words in the discourse database that ended in a word-final /p/; therefore it is excluded from comparison for this section.

The vowel plots were calculated using NORM, the vowel norminalization and plotting suite. The vowels were converted using the Bark Difference Metric, to allow for comparison between the two female and one male speakers. The formant values were plotted

for the group means of each vowel, /i/, /a/, /u/, and each of the three preceding /t/, /k/, /q/, with all speakers plotted on the same plot. The plot ellipses were all calculated using a standard deviation of 1.

In Figure 4, the vowel plots for each of the three vowels are presented and it is clear that there is a clear distinction between each of the vowels, with each vowel having its own range. This plot contains all 900 vowels tokens from the study.

Figure 4: Word–final vowels – 90% duration
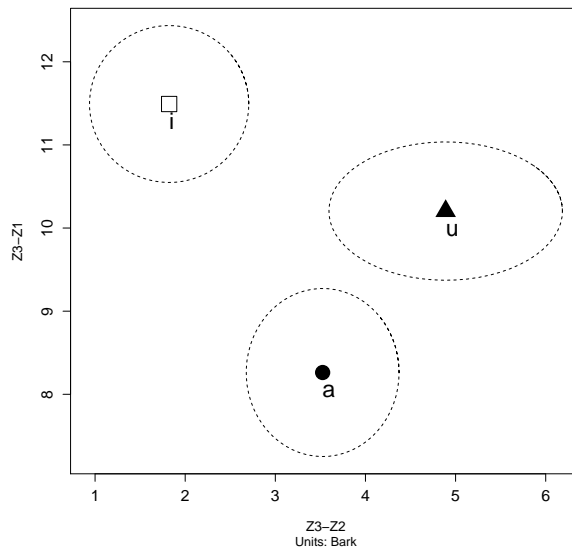
In order to determine whether there is evidence of articulatory movement, first the values of the pronounced word-final plosives were compared to the values of the vowels in Figure 4. This can be seen in Figures 5-8 below. Note that the ellipses for vowels preceding a plosive are denoted in the vowel plots as V_C, while the base vowel ellipses are denoted as V.
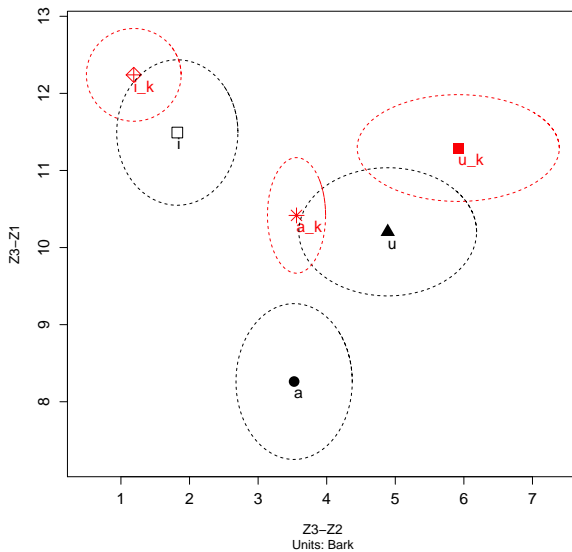
Figure 6: Word–final /k/ – 90% duration

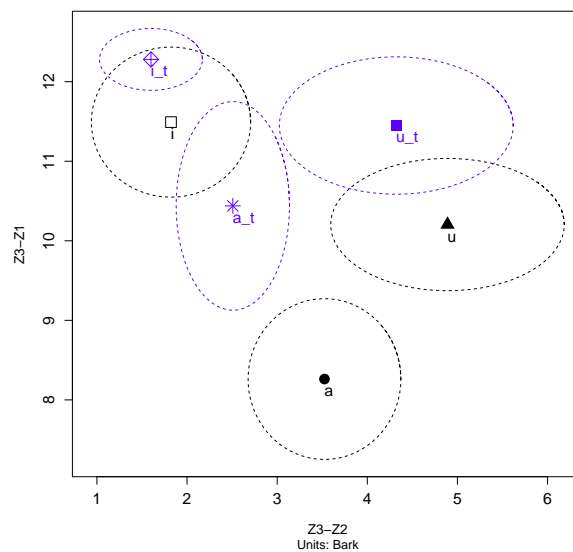**Figure 5: Word–final /t/ – 90% duration**

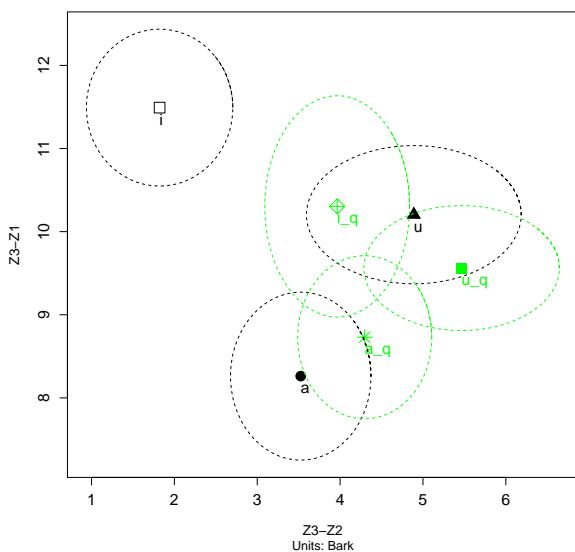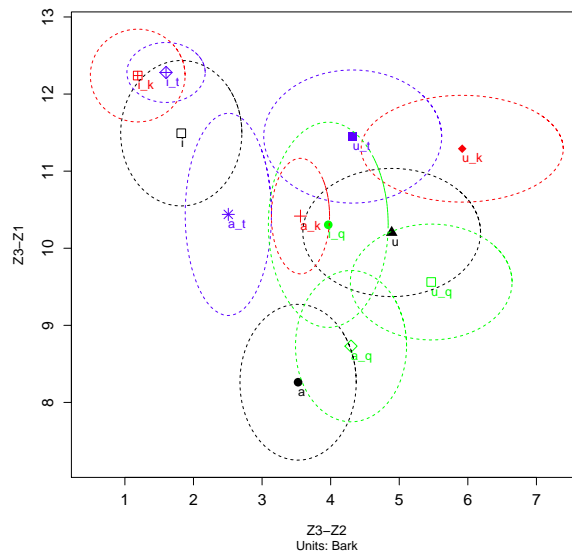**Figure 7: Word–final /q/ – 90% duration**

Figure 8: Word–final /t,k,q/ – 90% duration

For each of the three plosives, there are distinct patterns in the type of articulatory movement occurring. The next step to determining whether the 'dropped' plosives are unreleased or not is to compare the values of vowels preceding the unpronounced plosives with those from Figures 5-8. This is shown below in Figures 9-11. Note that here, the ellipses of the pronounced plosives are denoted as V_C, while the unpronounced plosives are denoted as V_*C.
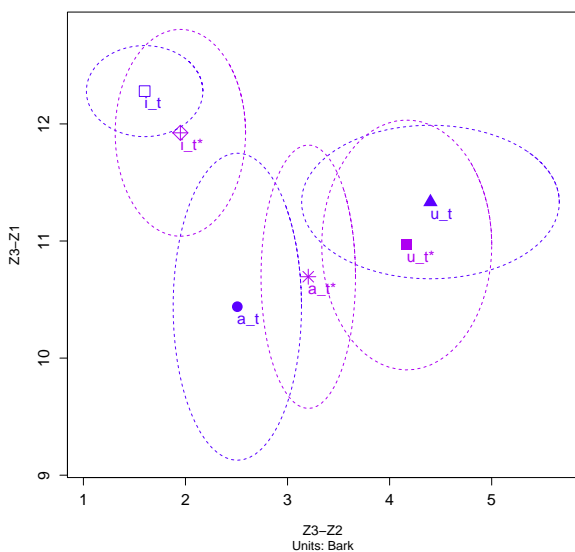
Figure 9: Word–final and unreleased /t/ – 90% duration

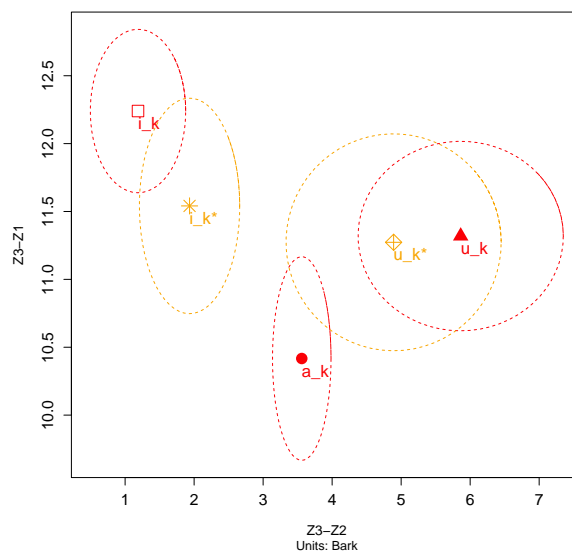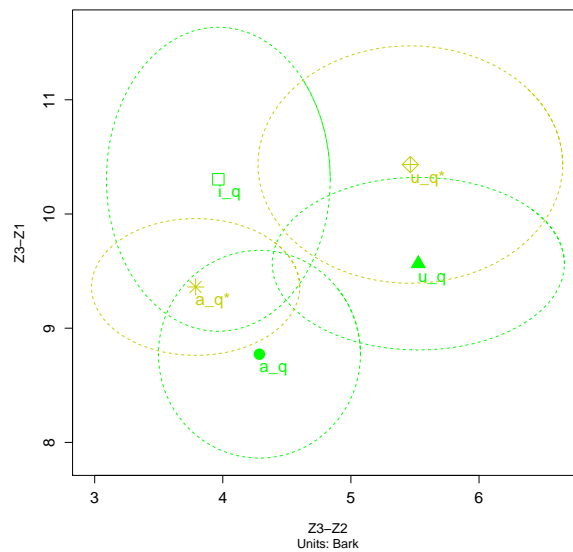**Figure 10: Word–final and unreleased /k/ – 90% duration**

Figure 11: Word–final and unreleased /q/ – 90% duration

As shown in Figures 9-11, the general values of the 'dropped' plosives match that of the pronounced values.[1] I take this as evidence that there is articulatory movement and as a result, the plosives are unreleased and not phonetically absent.

5. Conclusion

The results of this preliminary pilot study demonstrates that the 'dropped' plosives in word-final contexts are not phonetically null, but are rather unreleased. However, while the evidence from vowel plots suggests similar articulatory movement between the released and unreleased plosives, it remains to be seen if there is actually similar movement of the articulators. In order to determine this, an articulatory study is required. In addition, it remains to be seen if speakers of Inuktitut are able to perceive the unreleased plosives. That is, are they able to determine the type of unreleased plosive being pronounced in a context where there are no grammatical cues indicating the type of plosive. Further research into a perception study is also necessary. Finally, the study in this paper is all based on an online corpus, with limited data. A more detailed analysis with a complete set of proportional data and more speakers is also necessary to validate the preliminary results presented here, both for the word-final plosives, but also the VOT results indication a positive VOT and aspiration.

References

Allen, S. (1996). *Aspects of argument structure acquisition in Inuktitut*, volume 13. John Benjamins Publishing.

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[1]There are no values for -*ak* or -*iq* as there were no examples of in the dialogue database.

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