The low vowel and retraction in St'át'imcets*

Fusheini Hudu
The University of British Columbia

Previous phonetic studies show that St'át'imcets high vowels are produced with a lowered and backed tongue body and a retracted tongue-root when they occur adjacent to retracted consonants. The present study investigates whether an inherently low vowel would also show evidence for retraction or show opacity as observed crosslinguistically with other tongue root and tongue body phenomena, focusing on the two retracted conditions claimed in previous studies ([a] preceding and following retracted consonants). Results of the study show that compared to the position of the tongue-root in non-retracted conditions, the low vowel has a significantly more retracted tongue-root when it precedes retracted consonants. But no significant difference emerges between the tongue-root position for [a] following retracted consonants and [a] in non-retracted conditions. Thus even though the low vowel is not opaque to retraction in St'át'imcets, as far as tongue-root position is concerned, it only retracts preceding, but not following retracted consonants.

1 Introduction

Retraction in St'át'imcets is fairly well investigated (see Namdaran 2006; Bessell 1992, 1998; Remnant 1990; Shahin 1995, 1997, 2002; and van Eijk 1997). Much of the previous research has focused on retraction in consonants, making a distinction between pharyngeal resonants (ʕ, ʕ^{w}, ʕ', ʕ'^{w}) and uvular consonants (q, q^{w}, q' q'^{w}, χ, χ^{w},) that are inherently retracted, and coronals (c̲, c̲', s̲, l̲, l̲', and Lower dialect interdental *z, z'*) that are produced with retraction as a secondary articulation. Also established, is the fact that retraction in consonants has an effect on the articulation of neighbouring vowels. In detailed articulatory studies of retraction in St'át'imcets and Montana Salish, Namdaran (2006) and McDowell (2004) show that retraction in these Salish languages results in a lower and backed tongue position of the underlying non-retracted high vowels [i] and [u]. Still uninvestigated in these articulatory studies is what happens to the inherently low and back vowel /a/, when it occurs in aa

* Many thanks to Laura Thevarge for agreeing to take part in the study and sharing her knowledge of St'át'imcets with me, and to Lisa Matthewson for cross checking the data used in this study and for comments and help in designing this study. All errors are mine.

retracting condition in St'át'imcets: whether it is opaque to retraction or gets further lower when it occurs in a retraction context. This is what the present study is designed to investigate.

In the rest of this section, a number of theoretical issues and hypotheses relevant to the study are discussed. Section 2 presents an ultrasound imaging experiment used to investigate low vowel retraction. It also reports and discusses the results of the study. This is followed by final discussion and conclusion in Section 3.

1.1 Vowel retraction in St'át'imcets

Previous researchers are unanimous on various aspects of retraction in St'át'imcets. First, retraction takes place as two separate processes of assimilation (van Eijk 1997; Bessell 1992, 1998; Namdaran 2006). Local assimilation affects the quality of a vowel preceding a retracted consonant, while non-local assimilation is triggered by retracted roots, and affects coronals and vowels that occur in suffixes following the retracted roots. But there are differences in what exactly is involved in vowel retraction. One analysis for St'át'imcets and other Interior Salish languages is that when vowels adjacent to retracted consonants get retracted, the tongue-root is either lowered, backed or both (van Eijk 1997; Bessell 1992, 1998; Remnant 1990). It has also been described as involving two distinct gestures of the tongue root and tongue dorsum, processes that Shahin (1997, 2002 cited in Namdaran 2006) refers to respectively as "pharyngealisation" and "uvularisation". She argues, based on acoustic data, that "pharyngealisation" affects the vowels /i, u, a, e/ when preceding postvelar and retracted coronal consonants, as indicated by a medium rise in F1 and medium drop in F2, whereas "uvularization", (signaled by a medium/large rise in F1 and a large drop in F2) affects /a, ə, c/ when they precede retracted coronal consonants *s, l, l'*. Articulatory and acoustic studies by McDowell (2004) and Namdaran 2006) on Montana Salish and St'át'imcets respectively show that retracted vowels are produced with the tongue body moving in the direction of the rear pharyngeal wall.

Different claims have also been made regarding the directionality of the effects of retracted consonants and vowels. Early research (van Eijk 1997; Shahin 1997, 2002) concluded that local vowel retraction in St'át'imcets is restricted to only vowels that precede retracted consonants, ruling out retraction in the other direction. However, acoustic and articulatory studies by Bessell (1997) indicate that St'át'imcets vowels get retracted immediately following retracted consonants, even though the degree of retraction for vowels preceding retracted consonants is higher. Bessell's study is based on a higher F1 (which correlates with the lowering of the tongue dorsum) and lower F2 (which correlates with the backing of the tongue dorsum) obtained for the vowels /i, u, a, ə/ following /q and ʕ/ compared with the same values following the non-retracted consonants /p, t, k, ʔ/. These acoustic results are supported by Namdaran's (2006) acoustic and ultrasound study, which shows a symmetrical

effect in St'át'imcets vowel retraction, "such that the effect seen at the offset point in VC sequences was also seen at the onset point in CV sequences" (Namdaran 2006: 137). Namdaran's study also shows that the symmetry was more robust "for conditions /i, u/ adjacent to uvulars *q*, ʕ and /u/ adjacent to retracted coronal *s*, where offset/onset points for i/{q, ʕ} and u/s̲ showed a transitional configuration and offset/onset points for u/{q, ʕ} remained in the retracted position found at u/{q, ʕ}-midpoint" (Namdaran 2006: 137). Also similar to the results of Bessell's study is the finding by Namdaran (2006) of a higher degree of retraction for /i, u/ preceding the uvulars than following the same. Being an ultrasound study with its strength in producing articulatory data of the tongue that is free from other confounds such as the effects of lip gesture, Namdaran's study seems to produce the strongest evidence regarding the directionality for retraction in St'át'imcets. Still unanswered is the question of what the results of the low vowel /a/ might be. Using a procedure very similar to that used in Namdaran's study to address this question, the present study is a good logical step in contributing to the understanding of vowel retraction in St'át'imcets.

1.2 The low vowel

The low vowel /a/ raises unique questions on its own in the study of vowel retraction and other articulatory phenomena that affect tongue-root articulation. One such phenomenon that has received extensive discussion in the literature is tongue-root advancement. It has been observed (see Archangeli and Pulleyblank 1994, Pulleyblank et al 1995) in many languages that display cross-height tongue-root harmony that only non-low vowels are usually involved, with low vowels showing transparency or opacity to the harmony process. One explanation for this (e.g. Goad 1993) is that the low vowel cannot bear the phonological property of tongue-root advancement. In cases where such an advancement is perceived, the vowel must be a phonologically non-low vowel. Kaye et al (1985) also leave room for a low vowel with phonetically advanced tongue-root that does not show the phonological property of advancement.

A recent study by Gick et al (2006) however provides results to the contrary. In their ultrasound and acoustic study of Kinande, Gick et al found that low vowels in Kinande are phonological targets of tongue-root advancement in Kinande, as they significantly and systematically show tongue-root advancement and retraction in accordance with the rules of harmony in the language. Even though the present study does not investigate the phonological representation of low vowels in retracting environments, the question as to what happens to low vowels in contexts that trigger advancement/retraction is primarily a phonetic one. Thus the results of Gick et al (2006) raise questions as to what the articulatory properties of the tongue root are for low vowels in a context where non-low vowels have been found to show systematic tongue-body

gesture towards the rear pharyngeal wall (Namdaran 2006; McDowell 2004) and lowering and/or backing of the tongue root (van Eijk 1997).

Two conflicting hypotheses emerge out of previous accounts of St'át'imcets, related languages and languages with related articulatory phenomena. First, van Eijk (1997) and Shahin (1997, 2002) state that /a/ retracts and lowers to [ɑ] when in retracting contexts. Second, there is evidence for the backing of the tongue in Tunisian Arabic, as reported by Ghazeli (1977). These accounts would predict that the low vowel is not opaque to retraction, as it undergoes the same process in retracting conditions as non-low vowels in St'át'imcets.

The opposite prediction is made by McDowell (2004), whose acoustic results on Montana Salish suggest that the tongue position for /a/ advances when adjacent to retracted laterals /l, l', ɬ, and λ'/. The first hypothesis and the predictions it makes are adopted in this study, since they directly relate to previous claims on St'át'imcets. However, due to a number of constraints, including the non-availability of the relevant software, the present study will only consider tongue root values for low vowels in retracting and non-retracting conditions, but not entire tongues shapes for tokens in the different conditions, which is needed for testing the tongue-body lowering and backing hypothesis.

To sum up, the following hypotheses are tested in this study:
1). Vowel retraction affects low vowels in the same way as it affects non-low vowels. This hypothesis predicts that in retracting contexts, low vowels are produced with a lowering or backing of the tongue-root or both.
2). Directionally, retraction affects /a/ preceding as well as following a retracted consonant. However, vowels preceding retracted consonants will show more retraction than those following retracted consonants.

2 Testing the tongue-root values for /a/

2.1 Methods

2.1.1 Subject

A single female native speaker of St'át'imcets in her mid seventies who speaks the Lower dialect of the language was the only one available as a subject for the study.

2.1.2 Procedure

All the data were collected in the Interdisciplinary Speech Research Laboratory of the University of British Columbia. The subject was seated on a solid chair, while the English translations of the stimuli were read out to her. She was asked to embed a St'át'imcets translation of the stimuli in the phrase:

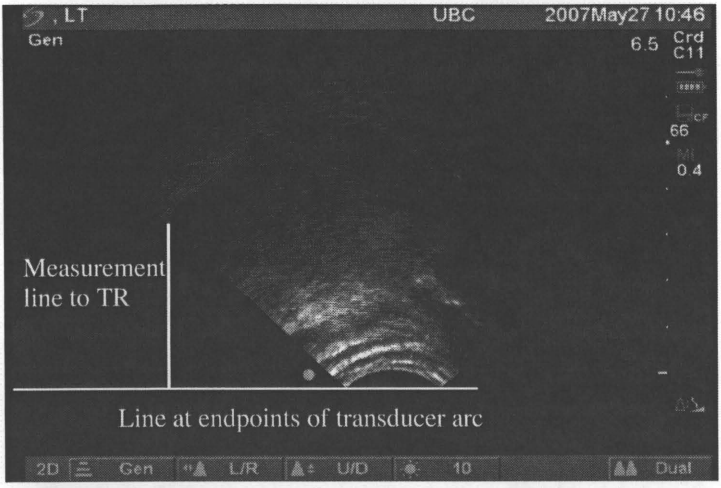
wæʔɬkæɬ tʃut___, "we say ___" a carrier phrase adopted from Namdaran (2006).[1] The stimuli were designed to elicit the low vowel in retracting as well as in non-retracting conditions. Preliminary data were verified with the subject to ensure that she was familiar with the words and pronounced them with the relevant conditions. Those she was not familiar with were often from the Upper Dialect. In the process, those that did not meet these standards were dropped. The transcription was also verified by Dr. Lisa Matthewson before any word was included in the statistical analysis. In the retracting condition, the stimuli were restricted to words in which /a/ preceded or followed the plain uvular stop /q/ or the plain uvular/pharyngeal approximant /ʕ/. In the non-retracting condition, I had only two words in my data that the subject was familiar with, and both had the low vowel between consonants that had very minimal or no effect on the tongue gesture. Thus in one, it was between two voiceless bilabial stops, and the other between /p/ and /l/. Besides consonantal context, stress was also controlled for, by ensuring that all tokens of the low vowel were stressed. The words were then randomized with distracter words and then presented to the subject in English. The subject was instructed to translate each word into St'át'imcets and embed it in the carrier phrase. The entire stimuli are shown in Appendix 1.

The ultrasound data were collected using a Sonosite Titan High-resolution portable ultrasound machine with a C11/8-5 MHz transducer at a standard rate of 29.97 frames per second (about 33 Hz). The transducer was held by the subject, who was instructed not to move her hand or head. The signal was visually monitored throughout the experiment for any head or hand movement, and any token for which any movement was observed or suspected to have occurred, or which did not show the image of the tongue clearly was re-recorded. After removing errorful data, 70 tokens were left that were used for this study.

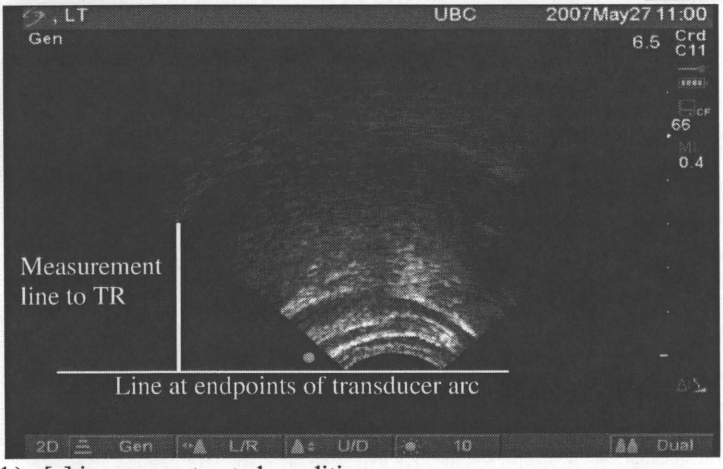
The ultrasound video was transmitted directly onto a Dell laptop computer using Adobe Premier, via an advanced digital video converter 110 Canopus that was connected to the computer through a firewire. Audio recording was done simultaneously using a Shure SM63LB unidirectional microphone fixed to a stand in front of the subject, and connected to the Canopus via a DMP3 dual microphone pre-amplifier. Thus both video and audio signals were properly synchronized. The frame for each vowel token was then extracted at the vowel mid points. A measurement software called ImageJ (http://rsb.info.nih.gov/ij/), which measures images and pictures in pixels, was used to determine the tongue root value for the tokens. First, a straight horizontal line touching the two ends of the transducer arc was established. A measurement line was drawn intersecting the horizontal line at 90 degrees to the lowest point in the tongue-root. Sample images are shown in figure 1, showing

[1] In Namdaran (2006), the carrier phrase ends with *ɬtæ/ɬti ʔuxʷælmíxʷtʃæ* "in Uxʷalmixʷc" But this last part of the phrase was dropped because the subject had problems translating the English equivalent.

the difference in the distance between the tongue root position and the base line for [a] in a retracted as well as non-retracted conditions.



a) [a]/ __ phar



b) [a] in a non-retracted condition

Figure 1. Diagrams showing ultrasound images of [a]. Frame (a) shows the mid point of [a] when it precedes /ʕ/, while frame (b) shows [a] when it occurs in a non-retracting condition. The relatively longer tongue root measurement line in (a) indicates a more retracted tongue root compared with (b).

2.2 Results

A comparison of [a] preceding a retracted consonant to [a] in a non-retracting condition shows a significant difference in the position of the tongue-root, with the former being about 11 pixels more retracted than the latter [ANOVA: $F(1, 37) = 1148.15$; $p < 0.0001$]. This is shown in Appendix 2a. In a comparison between [a] following retracted consonants and [a] in a non-retracted condition, the significance level depends on the consonant. When both uvulars and uvular pharyngeals are lumped together, no significance emerges between the two conditions, (Appendix 2b). But when the two retracted consonant are separated, [a]/ phar__ is significantly different from [a]/ lab[2].__ and [a]/ uv.___, with a difference of 13.5 pixels [ANOVA: $F(2, 47) = 1125.76$; $p < 0.0001$]. A comparison for each pair using student's t-test further shows a significant difference between them.: [a]/ phar.__ and [a]/uv.__ ($p < 0.0001$), [a]/ phar__ [a]/ lab.__ ($p < 0.0001$). However, against the prediction of the hypothesis, [a]/ lab__ has a more retracted TR than [a]/ uv.__ ($p < 0.0005$). This is shown in Appendix 2c. A similar pattern is observed in a comparison between the three conditions: [a]/ __Ret, [a]/ Ret.__, and [a]/ plain__. [a]/ __ Ret. is significantly more retracted than each of [a]/__Ret. And [a]/ lab__ ($p < 0.0001$), but no significant difference emerges between [a]/ __Ret. and [a]/ lab.__. A scattterplot for this is shown in Appendix 2d.

2.3 Discussion

The results of the tests provide evidence that low vowels are not opaque to retraction in St'át'imcets. They confirm previous analysis (see van Eijk 1997; Bessell 1992, 1998; Remnant 1990) to the effect that the low vowel undergoes the same effects as high vowels in retracting conditions, and that vowel retraction involves the backing of the tongue-root. Furthermore, the results are in harmony with Shahin's (1997, 2002) acoustic study that shows that retraction involves a tongue-root gesture which is triggered when preceding a pharyngeal.

However, the present study does not provide evidence for the bi-directionality of the effect of retracted consonants on adjacent vowels. Using tongue-root gesture as an indication of the effect of retracted consonants on adjacent vowels, the hypothesis that the low vowels following retracted consonants undergo retraction is not borne out. Instead, the results comes close to McDowell's (2004) finding for Montana Salish, which suggests that the tongue position for /a/ advances when adjacent to retracted laterals /l, l', ɬ, and λ'/.

[2] Non-standard abbreviations used here include the following: lab. = labial, phar. = uvular pharyngeal, Ret. = retracted, uv. = uvular.

3 Final discussion and conclusions

Focusing on only tongue-root position, the present study makes a unique contribution to the study of vowel retraction in St'át'imcets and Salish languages in a number of ways. First, it fills a gap in Namdaran's (2006) extensive study of retraction in St'át'imcets by adopting a methodology that is very close to her study (including the use of the same ultrasound machine, the same triggers of retractions in vowels, and the same data presentation technique). However, a number of gaps still remain in this study, the most notable being the use of only one speaker (and thus one dialect), and the restriction of the study to only tongue-root position. The latter was due partly to time constraints and the non-availability of the relevant software to carry out a comparison of the tongue images for vowels in the different test conditions. The fact that Namdaran's study focused on a comparison of entire tongue-shape for tokens in the various test conditions makes the focus of the two studies different. But in spite of not being the focus of this study, an impressionistic look at the images for the various retraction conditions and the non-retraction condition (as in Figure 1) shows that the shape of the tongue is different for each condition in a direction that would confirm Namdaran's results. Statistically backed claims will be left for future study. What needs to be stressed here is that the failure of the directionality hypothesis to emerge in the tongue-root studies is not sufficient to conclude that low vowels do not undergo retraction following retracted consonants. A comparison of measures of the tongue shape for tokens in the different test conditions is required before any conclusive claims can be made.

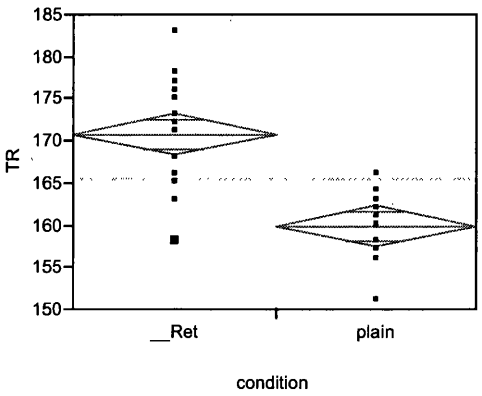
Second, being the first articulatory study to focus solely on the low vowel in St'át'imcets, it has evaluated previous claims that are based on impressionistic judgements (e.g. van Eijk 1997) and those that are based on indirect acoustic evidence (e.g. Shahin 1997, 2002).

Beyond St'át'imcets, this study is also of interest to crosslinguistic investigations into the phonetics and phonology of vowels. In particular, it contributes to a greater understanding of tongue-root phenomena, by showing evidence for the lack of opacity of the low vowel to tongue-root retraction, similar to what has been observed for tongue-root advancement (see Gick et al 2006), an understanding that could have implications for aspects of vowel phonologies such as vowel inventories and the conception of vowel features such as height and vowel harmony.

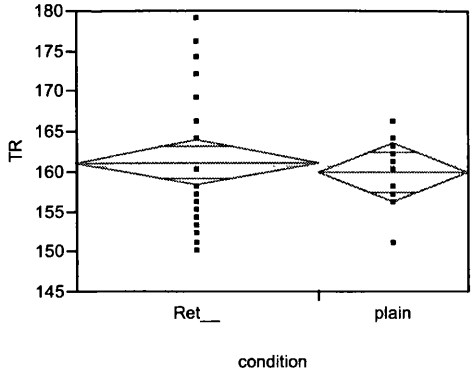
Appendix 1: Stimuli.

1. Retracted condition:	2. Non-retracted condition
a. [a]/ __ q	i. papt (always)
i. ʃjáqtʃa? (woman)	ii. pála? (one)
ii. máqin (hair)	
iii. máqa? (snow)	
b. [a]/ q__	
i. qá?əz' (tired)	
ii. ʃqáceza? (father)	
c. [a]/__ʕ	
i. pəʕpáʕ (grayish)	
ii. məʕmáʕ (light /bright)	
d. [a]/ ʕ__	
i. ʕap (evening)	

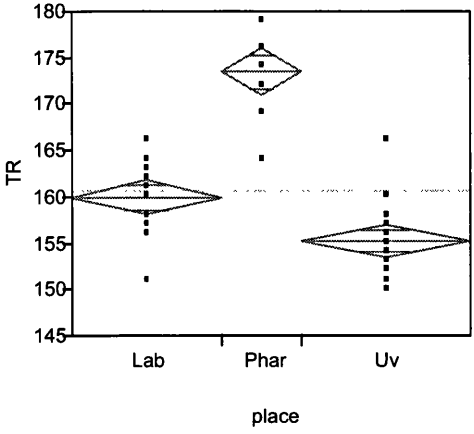
Appendix 2: Scatterplots of tongue-root values for various tests. Long horizontal lines in diamonds indicate mean values for each vowel, while short horizontal lines indicate upper and lower ends of 95% confidence intervals. Higher mean values indicate a higher degree of tongue-root retraction.



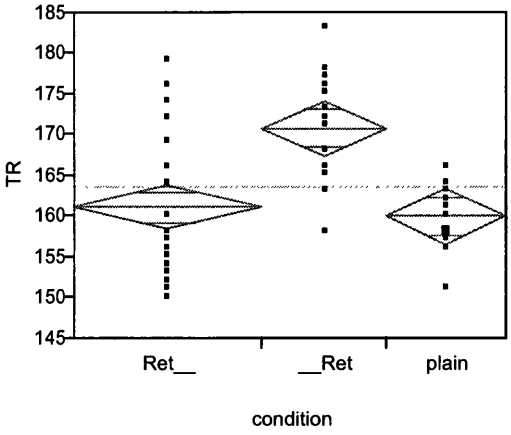
a) Low vowel in a retracted condition (preceding ʕ/q) versus [a] in a non-retracted condition.



b). Low vowel in a retracted condition (following ʕ/q) versus [a] in a non-retracted condition.



c. Low vowel in three conditions: following/preceding a labial, preceding a pharyngeal, and preceding a uvular.



d. Low vowel in three different conditions: preceded by a retracted consonant, preceding a retracted consonant and in a non-retracted condition.

References

Archangeli, D. & Douglas Pulleyblank. (1994). *Grounded Phonology.* Cambridge Massachusetts. MIT press.

Bessell, Nicola J. (1992). *Towards a Phonetic and Phonological Typology of Post-Velar Articulation.* Doctoral dissertation. The University of British Columbia.

Bessell, N. J. (1998). Phonetic aspects of retraction in Interior Salish. In *Salish Languages and Linguistics: Theoretical and Descriptive Perspectives*, eds. Ewa

Ghazeli, S. (1977). *Back Consonants and Backing Coarticulation in Arabic.* Doctoral dissertation, University of Texas at Austin.

Goad, H. (1993). *On the configuration of height features.* PhD dissertation, University of Southern California.

Gick, B., Douglas Pulleyblank, Fiona Campbell & Ngessimo Mutaka. (2006). Low vowels and transparency in Kinande. In *Phonology* 23 1–20. Cambridge, Cambridge University Press

Kaye, J., Jean Lowenstamm & Jean-Roger Vergnaud (1985). The internal structure of phonological elements: a theory of charm and government. Phonology Yearbook 2. 305–328.

McDowell, R. E. (2004). *Retraction in Montana Salish Lateral Consonants.* M. A. thesis. University of British Columbia.

Namdaran, N. (2006). *Retraction in St'át'imcets, an ultrasonic inverstigation.* Master Thesis. The University of British Columbia.

Pulleyblank, D., Ping Jiang-King, Myles Leitch, & Ọlanikẹ Ọla. (1995). Typological variation through constraint rankings: low vowels in tongue root harmony. In *Proceedings of South Western Optimality Theory Workshop*. The University of Arizona Coyote Papers, 184-208.

Remnant, D. (1990). *Tongue root articulations: A case study of Lillooet.* M.A. thesis, University of British Columbia.

Shahin, K. (1995). On the distinction between pharyngealisation harmony and uvularisation harmony in St'át'imcets (Lillooet Salish). *International Conference on Salish and Neighboring Languages,* 30: University of Victoria.

Shahin, K. (1997). *Post-velar Harmony.* Doctoral dissertation, University of British Columbia.

Shahin, K. (2002). *Post-velar harmony.* Philadelphia: John Benjamin.

van Eijk, J. (1997). *The Lillooet Language: Phonology, Morphology, and Syntax.* Vancouver: University of British Columbia Press.

Fusheini Hudu
Buchanan E 270, 1866 Main Mall
The University of British Columbia
Vancouver, BC. Canada. V6T 1Z1.

Hudu28@gmail.com