

Fusheini Hudu

The Low Vowel and Retraction in St'át'imcets: An Ultrasound Investigation¹

Abstract

Previous phonetic studies show a co-articulatory effect of retracted consonants on adjacent high vowels resulting in tongue-root retraction and tongue-body lowering. The present study uses ultrasound imaging to investigate whether an inherently low vowel would also show evidence for retraction or show opacity as observed cross-linguistically with other tongue root and tongue body phenomena. Focusing on the two retracted conditions claimed in previous studies (VC and CV sequences with retracted consonants), results of the present study show that compared to the position of the tongue-root in non-retracted contexts, the low vowel has a significantly more retracted tongue-root when it precedes retracted consonants. No significant difference in tongue-root position is observed between /a/ in a CV sequence with retracted consonants and /a/ in a non-retracted context. Thus even though the low vowel is not opaque to retraction in St'át'imcets, it retracts only when preceding consonants, not following retracted consonants.

1. Introduction

1.1 Retraction in St'át'imcets

St'át'imcets, also known as Lillooet Salish, is a critically endangered language spoken by less than a 100 people (Henry Davis p.c.) in an area of southwest Interior British Columbia, Canada. It belongs to the Northern Interior branch of the Salishan language family. The language has two major dialects, the Upper and Lower dialects, which differ in syntax,

¹ Many thanks to Laura Thevargé for taking part in the study and sharing her knowledge of St'át'imcets with me, to Dr. Lisa Matthewson for cross checking the data used in this study and for comments and help in designing this study. I also thank Dr. Bryan Gick for suggestions on the set up of the experiment and to two anonymous reviewers for very useful comments. All errors are mine. The name of the language is spelt 'St'át'imcets' in the practical orthography. The IPA transcription is ʃtʰ'ætʰ'ɪmxətʃ .

phonology and lexicon (see van Eijk 1997 for further discussion on dialectal difference). Typical of all Interior Salish languages, St'át'imcets has a rich consonant inventory, with over 40 phonemes, 17 of which are retracted. By contrast, there are only 4 vowels in the language: /i/, /u/, /a/, and epenthetic /ə/. The schwa is a predictable vowel with variable surface qualities that is epenthesised to break certain consonant clusters (Matthewson 1994) and to preserve the prosodic structure of the language (see Shahin 1997, 2002; van Eijk 1997; Namdaran 2006 for further discussion).

Retraction in St'át'imcets and other Interior Salish languages is fairly well investigated (see Namdaran 2006; McDowell 2004; 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 (/tʃ/, /tʃ^s/, /s/, /ʃ/, /l'/ and Lower dialect interdental /ð/, /ð'/) that are produced with retraction as a secondary feature. 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 languages results in a lower and backed tongue position of the underlying non-retracted high vowels /i/ and /u/. What happens to the inherently low and back vowel /a/ when it occurs in a retracting context in St'át'imcets, whether it is opaque to retraction or gets further lower, is a question that is still uninvestigated in any articulatory study. This is what the present study is designed to address.

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. Section 3 concludes the paper.

1.2 Vowel retraction in St'át'imcets and Interior Salish

Previous research (e.g. van Eijk 1997; Bessell 1992, 1998; Namdaran 2006) is unanimous on some aspects of vowel retraction in St'át'imcets. First, St'át'imcets is like other languages with retracted segments such as Arabic, in that vowel retraction is a co-articulatory effect from adjacent inherently retracted consonants. Second, retraction takes place as two

separate processes of assimilation. Local assimilation affects the quality of a vowel when it precedes a retracted consonant, non-local assimilation is triggered by retracted roots, targeting coronals and vowels that occur in suffixes following the retracted roots.

However, previous accounts differ on exactly what is involved in vowel retraction. Accounts of St'át'imcets and other Interior Salish languages (e.g. van Eijk 1997; Bessell 1992, 1998; Remnant 1990) describe the co-articulatory effects of retracted consonants on adjacent vowels as resulting in the lowering or backing of the tongue-root during the production of the vowels, or both processes. These accounts differ from that of Shahin (1997, 2002), who describes retraction as two distinct gestures involving not only the tongue-root, but also the tongue-dorsum. Shahin refers to these processes as “pharyngealisation” and “uvularisation” respectively. She argues, based on acoustic data, that “pharyngealisation” affects the vowels /i/, /u/, /a/, /ə/ when preceding post velar and retracted coronal consonants, as indicated by a medium rise in F1 and medium drop in F2. By contrast “uvularisation”, (signaled by a medium/large rise in F1 and a large drop in F2) affects the vowels /a/ and /ə/ when they precede retracted coronal consonants /ʂ/, /ʈ/, /ʈʰ/. More recent acoustic and ultrasound studies on Montana Salish (McDowell 2004) and St'át'imcets (Namdaran 2006) respectively show that retracted vowels are produced with the tongue body moving towards the rear pharyngeal wall.

Different claims have also been made regarding the directionality of co-articulation of retracted consonants and vowels. Early research (van Eijk 1997; Shahin 1997, 2002) concluded that local vowel retraction in St'át'imcets is restricted only to vowels that precede retracted consonants (VC sequences); ruling out retraction for vowels that follow retracted consonants (CV sequences). However, acoustic and articulatory studies by Bessell (1997) indicate that St'át'imcets vowels can be 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 /ʂ/ 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. Results of her study show 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 found that the symmetry was more robust for the vowels /i, u/ adjacent to inherently retracted uvulars /q/, /ʕ/ and the vowel /u/ adjacent to retracted coronal /ʃ/.

Results of Namdaran (2006) are similar to that of Bessell’s. She found that /i, u/ have a higher degree of retraction when they occur in VC sequence with uvulars than when they occur in CV sequence. 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 uninvestigated is the behaviour of the low vowel /a/ in retraction contexts. To fill this gap, and as a contribution to the understanding of vowel retraction in St’át’imcets in general, the present study investigates the low vowel using ultrasound imaging.

1.3 The low vowel

The low vowel /a/ raises unique questions in the study of vowel retraction and other articulatory phenomena that affect tongue-root articulation. One such phenomenon that has received extensive discussion crosslinguistically is tongue-root advancement. Archangeli and Pulleyblank (1994) observe that in cross height harmony patterns, the low vowel may undergo, block, or be transparent to the spread of harmony. One explanation (e.g. Goad 1993) for languages in which the low vowel is opaque or transparent to the spread of harmony is that the low vowel cannot bear the phonological property of tongue-root advancement. In cases where such advancement is perceived, the vowel must be a phonologically non-low vowel. Kaye et al. (1985) also argue for the possibility of the low vowel having a phonetically advanced tongue-root that does not show advancement as a phonological feature.

Recent studies (e.g. Gick et al. 2006) however provide results to the contrary. Based on ultrasound and acoustic data, Gick et al. found that low vowels are phonological targets of tongue-root advancement, as they systematically show tongue-root advancement and retraction in accordance with the rules of harmony in Kinande, a Bantu language of the democratic Republic of Congo. 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 relevant because it is primarily a phonetic one.

One of the questions the results of Gick et al. (2006) raise is 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 in previous accounts of St'át'imcets (e.g. van Eijk 1997); related languages (McDowell 2004) and languages with related articulatory phenomena (Shahin 1997, 2002).

The first hypothesis is that /a/ lowers/retracts when adjacent to retracted consonants. In support of this hypothesis is the claim by Shahin and van Eijk that /a/ retracts and lowers to [ɒ] when preceding retracting consonants. Ghazeli's (1977) claim that tongue backing occurs in Tunisian Arabic also supports this hypothesis. These accounts 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 second hypothesis makes the opposite claim; that St'át'imcets /a/ advances in contexts where other vowels are found to retract. This is predicted by McDowell's (2004) acoustic study of Montana Salish which reports a raising F2 for /a/ when adjacent to retracted laterals /l/, /l'/, /ʎ/, and /tʃ'/. The results suggest that the tongue position advances in these contexts. By comparing the position of the tongue-root in the production of /a/ in retracting contexts to those in non-retracting contexts, the present study tests these hypotheses.

Finally, this study will test the directionality hypothesis. Namdaran (2006) found evidence for retraction in high vowels, both in VC and CV sequences, even though the co-articulatory effect in the CV sequence was not as robust as that of the VC sequence. If, like the high vowels, /a/ retracts in VC sequence, it is quite likely that it would also retract in CV sequences, as found for high vowels in Namdaran's study, even if to a lesser degree. On the other hand, if /a/ does not retract in VC sequence, the prediction is that it would not retract when following retracted consonant. Consistent with the prediction that /a/ retracts before retracted consonants; the present study predicts that /a/ will also retract following retracted consonants. Table (1) summarises the hypotheses tested in this study. Section 2 presents the ultrasound imaging experiment used to test these hypotheses.

2. Experiment

2.1 Hypothesis

Results of Namdaran (2006), the only articulatory study of vowel retraction effects in St'át'imcets, show that movement of the tongue-root towards the lower pharyngeal wall is the largest gesture for the vowels [i] and [u] when they occur in retraction contexts, even though the lowering of the tongue-body is also observed. The present study extends this finding by testing for tongue-root retraction for the low vowel /a/.

Table 1. Summary of hypotheses on low vowel retraction in St'át'imcets.

	hypothesis	prediction
1.	Vowel retraction affects low vowels in the same way as it affects non-low vowels.	In retracting contexts, /a/ has a more backed tongue-root compared to plain context.
2.	Retraction affects /a/ both when it precedes and when it follows a retracted consonant, although it may be more retracted preceding than following retracted consonants.	Compared to a plain context, /a/ has a more backed tongue-root both preceding and following a retracted consonant.
3.	St'át'imcets /a/ advances in contexts where other vowels are found to retract.	In retracting contexts, the position of the tongue-root for /a/ is more anterior than in non-retracting contexts.

2.2 Methods

2.2.1 Subject

One female native speaker of the Lower dialect of St'át'imcets in her mid-seventies participated in the study. Testing more speakers from both dialects of the language would have produced a more representative data sample. However, due to several constraints, including the limited resources available, the relatively new technology involved and the paucity of the few remaining fluent speaker available in the Vancouver area, I was unable to include more speakers for this study.

2.2.2 Stimuli

The stimuli were designed to elicit the low vowel in retracting as well as in non-retracting contexts. Preliminary data were verified with the subject to ensure that she was familiar with the words and pronounced them with the relevant desired contexts. Most of the words she was not familiar with were from the Upper Dialect. The transcription was also verified by an expert on the language before any word was included in the analysis.

The retracting condition consisted of words in which /a/ preceded or followed the plain uvular stop /q/ or the plain uvular/pharyngeal approximant /ʕ/, shown in (2). The non-retracting condition placed the low vowel between labials and alveolars to minimise the consonantal effect on the tongue-root gesture (1). Stress was also controlled for, by ensuring that all tokens of the low vowel were stressed. The words were then randomised with distracters and presented to the subject in English.

(1) Non-retracted condition

papt 'always'

pálaʔ 'one'

(2) Retracted condition

a. /a/ /__ q

i. *ʃjáqʔaʔ* 'woman'

ii. *máqin* 'hair'

iii. *máqaʔ* 'snow'

b. /a/ /q__

iv. *qáʔəð* 'tired'

v. *ʃqáʔfeðaʔ* 'father'

c. /a/ /__ ʕ

vi. *pəʃpáʕ* 'grayish'

vii. *məʃmáʕ* 'light /bright'

d. /a/ /ʁ__

viii. *ʃap* ‘evening’

2.2.3 Procedure

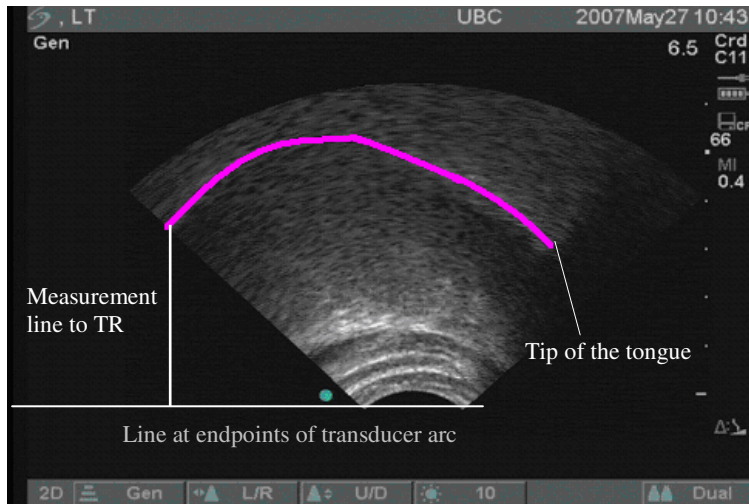
All the data were collected in the Interdisciplinary Speech Research Laboratory of the University of British Columbia. The subject was seated on a solid chair, while the English translations of the stimuli were read out to her. She was instructed to embed a St’át’imcets translation of the stimuli in the phrase: wæʔʰkæʰ tʃut, “we say ___” a carrier phrase adopted from Namdaran (2006).²

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. 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 used for the analysis: 12 tokens in non-retracted condition (preceding/following a labial); 13 tokens preceding a uvular, 13 tokens preceding a uvular pharyngeal, 17 tokens following a uvular, 15 tokens following a uvular pharyngeal.

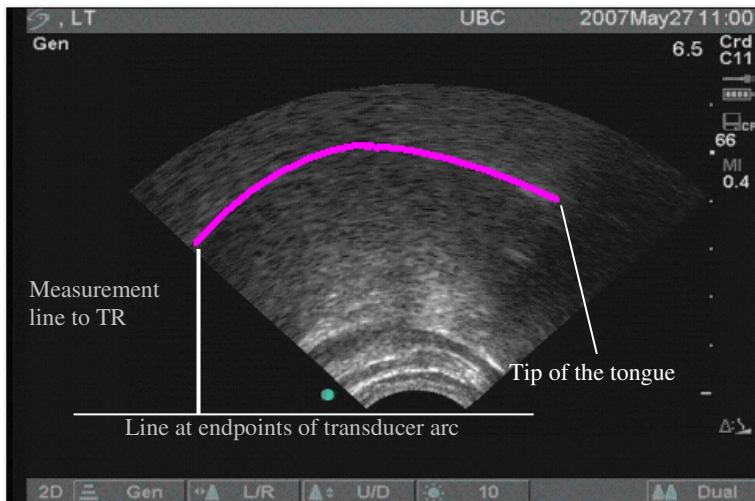
The ultrasound video was recorded directly onto a Dell laptop computer using Adobe Premier, via an advanced digital video converter 110 Canopus connected to the computer. Audio recording was done simultaneously using a Shure SM63LB unidirectional microphone fixed to a stand in front of the subject and connected to the Canopus via a DMP3 dual microphone pre-amplifier, ensuring both video and audio signals were properly synchronized. The mid-point frame for each vowel token was then extracted from the video. A straight line touching the lowest points in the ultrasound transducer arc was used as the base for obtaining tongue-root values. Measurement was done with the use of ImageJ (<http://rsb.info.nih.gov/ij/>), a software that measures images and pictures in

² In Namdaran (2006), the carrier phrase ends with ʰtæ/ʰti ʔux^wælmíx^wtʃæ ‘in Ux^wælmíx^wtʃæ. This part of the phrase was dropped because the participant had problems translating the English equivalent.

pixels. The measurement line was drawn intersecting the horizontal line at an angle of 90 degrees to the lowest point in the tongue-root. Figure 1 has sample images showing the difference of the distance between the tongue root position and the base line for /a/ in retracted as well as non-retracted conditions.



a) /a/ /__ʔ

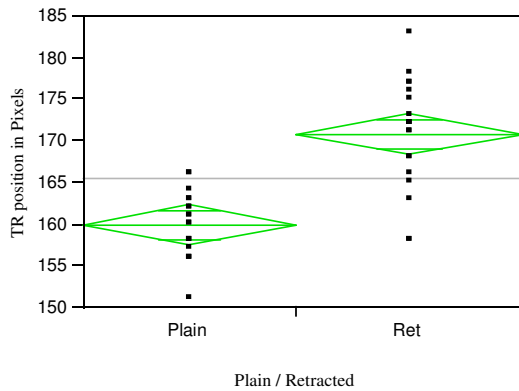


b) /a/ in a non-retracted condition

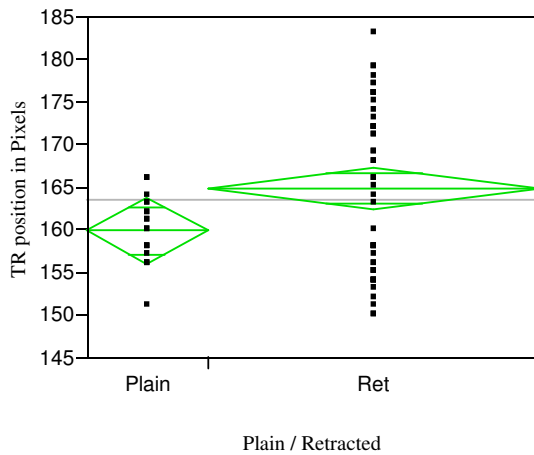
Figure 1. Tracing of midsagittal ultrasound images of St'át'imcets /a/. Frame (a) shows the mid point of /a/ when it precedes /ʔ/. Frame (b) shows /a/ when it occurs in a non-retracting condition. The longer tongue-root measurement line in (a) indicates a more retracted tongue root compared with (b).

2.3 Results

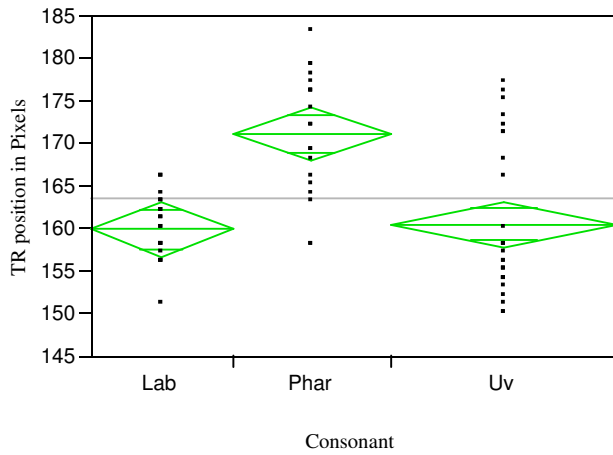
A comparison of /a/ preceding a retracted consonant to /a/ in a non-retracting condition shows significant difference in the position of the tongue-root. The tongue-root is about 11 pixels more retracted when /a/ precedes a retracted consonant (ANOVA: $F(1, 37) = 1148.15$; $p < 0.0001$). A scatterplot for this is shown in Figure 2(a).



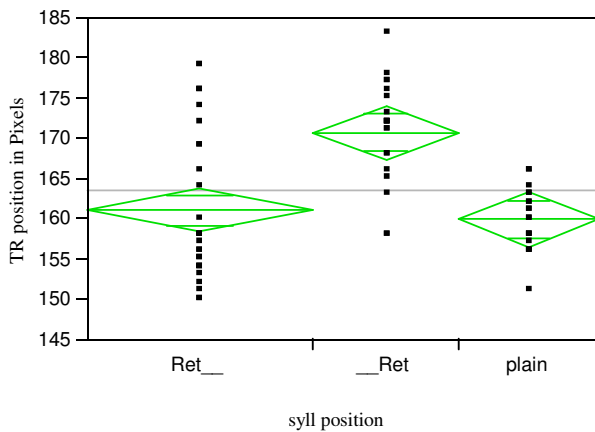
(a) Low vowel in a retracted condition (preceding $\text{ʌ}/\text{q}$) versus /a/ in a plain condition.



(b) Low vowel in a retracted condition (following $\text{ʌ}/\text{q}$) versus /a/ in a plain 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: following a retracted consonant (Ret_), preceding a retracted consonant (__Ret), and in a non-retracted condition (Plain).

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

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 pooled, no significant

difference is observed between the two conditions, as the scatterplot in Figure 2(b) shows. When the two retracted consonant are separated, /a// phar__ is significantly different from /a// lab__ and /a// uv__ (ANOVA: $F(2, 67) = 871.791$; $p < 0.0001$). 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, there is no significant difference between /a// uv__ and /a// lab__ This is shown in Figure 2(c).

A similar pattern is observed in a comparison between the three retracted conditions: /a// __Ret, /a// Ret__, and /a// plain. /a// __ Ret is significantly more retracted than each of /a//Ret__ and /a// plain ($p < 0.0001$); whereas no significant difference is observed between /a// __Ret and /a// plain. A scatterplot for this is shown in Figure 2(d). Table 2 summarises results of all the comparisons.

Table 2. A comparison of /a/ retraction in various contexts.

	Mean difference in pixels	p value
Syllable contexts		
phar__ > uv__	10.64	$p < 0.0001$
phar__ > lab__	11.25	$p < 0.0001$
uv > lab__	0.60	NS
Retracted/ directional contexts		
__Ret > plain	10.86	$p < 0.0001$
__Ret > Ret__	9.65	$p < 0.0001$
Ret __ vrs. plain	1.2	N.S.

2.4 Discussion

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

root gesture which is triggered when preceding a pharyngeal, an effect she refers to as “pharyngealisation”.

However, the present study does not provide evidence for the bi-directionality of the co-articulatory effect of retracted consonants on adjacent vowels. Using tongue-root position, the most reliable and consistent distinguishing gesture between plain and retracted vowels, as an indication of this co-articulatory effect, the hypothesis that low vowels in CV sequence with retracted consonants undergo retraction is not borne out.

3. Conclusions

The present study contributes to the understanding of vowel retraction in St'át'imcets and Salish languages in a number of ways. First, being the only articulatory study to focus on the low vowel in St'át'imcets, it has evaluated previous claims that are based on impressionistic judgements of what happens to /a/ in retraction contexts (e.g. van Eijk 1997) and those that are based on indirect acoustic evidence (e.g. Shahin 1997, 2002). Second, it fills a gap in Namdaran's (2006) extensive study of retraction in St'át'imcets which does not investigate the low vowel.

The 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). This has implications for aspects of vowel phonologies such as vowel inventories and the conception of vowel features such as height and vowel harmony.

Some aspects of low vowel retractions in St'át'imcets which have not been investigated here still deserve future investigation. First, future study may include speakers of the Upper dialect, although consistent with previous phonetic studies, results of this dialect are not expected to show any significant difference from those of the Lower dialect. Second, future investigation of the position of the tongue-body, which is found to be lowered as part of the co-articulatory effects on high vowels [i] and [u] (Namdaran 2006), will show if an inherently low vowel will also undergo the same effect. Finally, while the results here is sufficient to conclude that low vowels do not undergo tongue-root retraction following retracted consonants, future studies need to compare the positions of the tongue-body for tokens in the different test conditions to determine whether the

tongue-body is lowered in either (CV or VC) sequences, as found for high vowels.

References

- Archangeli, Diana & Pulleyblank, Douglas (1994) *Grounded Phonology*. Cambridge Massachusetts: MIT press.
- Bessell, Nicola (1992) *Towards a Phonetic and Phonological Typology of Post-Velar Articulation*. Doctoral dissertation. The University of British Columbia.
- (1998) Phonetic aspects of retraction in Interior Salish. In Ewa Czaykowska-Higgins & M. Dale Kinkade (eds.), *Salish Languages and Linguistics: Theoretical and Descriptive Perspectives*, pp. 125–152. Berlin: Mouton de Gruyter.
- Deterding, David (1997) The formants of monophthong vowel in Standard Southern British English pronunciation. *Journal of the International Phonetic Association* 27: 47–55.
- Ghazeli, Salem (1977) *Back Consonants and Backing Coarticulation in Arabic*. Doctoral dissertation. University of Texas at Austin.
- Goad, Heather (1993). *On the configuration of height features*. Doctoral dissertation. University of Southern California.
- Gick, Bryan; Pulleyblank, Douglas; Campbell, Fiona & Mutaka, Ngessimo (2006) Low vowels and transparency in Kinande. *Phonology* 23: 1–20.
- Hawkins, Sarah & Midgley, Jonathan (2005) Formant frequencies of RP monophthongs in four age groups of speakers. *Journal of the International Phonetic Association* 35: 183–199.
- Kaye, Jonathan; Lowenstamm, Jean & Vergnaud, Jean-Roger (1985) The internal structure of phonological elements: a theory of charm and government. *Phonology Yearbook* 2: 305–328.
- Matthewson, Lisa (1994) Syllable structure in St'át'imcets. In Päivi Koskinen (ed.), *Proceedings of the 1994 Annual Conference of the Canadian Linguistics Association (Toronto Working Papers in Linguistics)*. Toronto: Department of Linguistics, University of Toronto.
- McDowell, Ramona. E. (2004) *Retraction in Montana Salish Lateral Consonants: An ultrasonic study*. M.A. thesis. University of British Columbia.
- Namdaran, Nahal (2006) *Retraction in St'át'imcets: an ultrasonic investigation*. M.A. thesis. The University of British Columbia.
- Remnant, Daphne (1990) *Tongue root articulations: A case study of Lillooet*. M.A. thesis. University of British Columbia.
- Shahin, Kimary (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.
- (1997) *Post-velar Harmony*. Doctoral dissertation. University of British Columbia.
- (2002) *Post-velar harmony*. Philadelphia: John Benjamin.

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

Contact information:

Fusheini Hudu
Department of Linguistics
Totem Fields Studios
2613 West Mall
University of British Columbia
Vancouver, British Columbia V6T 1Z4
Canada
e-mail: hudu28(at)gmail(dot)com