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THE NATURE OF LARYNGEALIZATION IN ST'ÁT'IMCETS LARYNGEALIZED RESONANTS[1]

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Phonetic variability—the variability with which we speak—has recently received much attention because of its implications for how sounds are represented lexically. This paper considers phonetic variability in laryngealized resonants, which are rare cross-linguistically but common in the Pacific Northwest languages (Salish and Wakashan). Previous literature on these sounds has focused primarily on variability in timing between the oral and laryngeal gestures. This paper explores instead variability in the realization of the laryngeal gesture, focusing on St'át'imcets (Lillooet Salish). Pitch, amplitude, and duration measurements are taken to characterize the laryngeal gesture of intervocalic laryngealized resonants. Results exhibit a high degree of variability but show that, overall, realization depends primarily on the location of the laryngealized resonant with respect to word stress: the correlates of laryngealization are acoustically stronger in post-stress than in pre-stress position. Results are discussed in terms of their possible causes and in terms of their implications for how sound structure is lexically encoded.

[Keywords: St'át'imcets, Salish, laryngealized resonants, phonetic realization, phonetic variability]

1. Introduction. Phonetic investigations have shown that speech production involves an enormous amount of phonetic variability (see, e.g., Gerfen and Baker 2004 and Pierrehumbert and Frisch 1996 on variability in glottal and laryngeal articulations). Laryngealized resonants[2]—described in detail below—are ideal for studying this variability because they vary along two dimensions: the realization of the laryngeal gesture and the timing of this gesture relative to the oral one(s). While timing has been explored in detail in many languages (see Bird et al. 2008 for a summary of the relevant literature), realization has so far received very little attention. The goal of this paper is to take a step toward filling this gap by considering the realization of the laryngeal gesture of laryngealized resonants in St'át'imcets (Lillooet Salish), a Northern Interior Salish language.

Section **2** provides a general introduction to the variable pronunciation of laryngealized resonants and to the St'át'imcets language. Section **3** presents

[1] Many thanks to Aggie Patrick, Carl Alexander, and Linda Redan for sharing their language, and to Marion Caldecott, Henry Davis, Allison Morrill, and Laticia Walker for all their help. All errors are my own.

[2] Also referred to as "glottalized resonants." The term "laryngealized" is used here as a more accurate description of the articulation of these sounds.

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the details of an experiment designed to study the phonetic realization of laryngealized resonants in this language. Section **4** begins with a discussion of variability, goes on to consider possible causes for the observed patterns, and ends with a proposal of how speakers lexically encode the phonetic details of these sounds.

2. Background. Laryngealized resonants (hereafter referred to as LRs) are relatively rare sounds, reported in 20 of the 317 languages surveyed by Maddieson (1984). They are characterized by at least two gestures: a laryngeal one and an oral one. For example, [y'] involves tongue-body raising (oral gesture) in addition to laryngeal constriction (laryngeal gesture). Laryngealized resonants vary along two dimensions: the timing of the laryngeal gesture with respect to the oral one(s) and the exact realization of the laryngeal gesture.

Timing in LRs has been documented for many languages (see Gordon and Ladefoged 2001 and Bird et al. 2008 for a review of the literature) and has been at the center of several proposals on why the same articulatory timing patterns occur again and again across languages (Silverman 1997, Steriade 1997, Howe and Pulleyblank 2001, and Bird et al. 2008). This is because, compared to many articulatorily complex segments, LRs are characterized by relative independence between the component oral and laryngeal gestures (Kingston 1990). Indeed, many segments involving multiple gestures use the same broad articulatory structure for all of them, most often the tongue. For example, in the production of [l], the two primary gestures are tongue-tip raising and tongue-body backing (Sproat and Fujimura 1993 and Gick et al. 2006). Although the tongue tip and back are to a certain degree independent from one another, they are much more closely bound than are the tongue and the larynx—the primary articulators involved in the pronunciation of LRs. The more independent component gestures are from one another, the less likely it is that recurring timing patterns involving these gestures are due to universal articulatory restrictions. Laryngealized resonants have figured prominently in the literature because, due to the relative independence of the gestures involved, they present a reasonably clear case for understanding what factors other than universal articulatory restrictions might be at play in establishing recurrent timing patterns, e.g., perceptual salience (Mattingly 1981, Silverman and Jun 1994, Byrd 1994; 1996*a*; 1996*b*, Wright 1996, Silverman 1997, Chitoran, Goldstein, and Byrd 2002, and Kochetov 2002; 2006).

The other way in which LRs exhibit substantial variability is in the realization of the laryngeal gesture: from a complete stop to a small dip in fundamental frequency. This variability is similar to that found in the pronunciation of glottal stop in languages like English (Hillenbrand and Houde 1996 and

Pierrehumbert and Frisch 1996) and laryngealized vowels in languages like Coatzospan Mixtec (Gerfen and Baker 2004). Variability in the realization of LRs has so far received very little attention; understanding this variability will shed important light on the kinds of restrictions (articulatory and perceptual) which determine how speech sounds tend to be produced. It will also lead to a better understanding of how sounds are represented lexically, i.e., to what extent the details of their phonetic implementation are specified. To learn more about the articulation of LRs, an experiment was designed and conducted on the realization of the laryngeal gesture in these complex sounds, in one particular language: St'át'imcets Salish.

St'át'imcets (Lillooet) Salish is a Northern Interior Salish language, comprising two (possibly three) dialects: Upper and Lower (and Douglas, possibly a branch of Lower). It is spoken in 11 bands in the interior of British Columbia, in a roughly triangular area between Mount Currie (west), Pavilion (east), and Port Douglas (south). There are approximately 100 fluent speakers remaining, all over the age of 60 (http://www.uslces.org/uslces.html). These speakers are also fluent in English, the language of daily communication. Like other Salish languages, St'át'imcets has an extremely rich consonant inventory, outlined in table 1. This table is based on van Eijk (1997:2); the LRs are in boldface.[3]

Each LR has a non-laryngealized counterpart. According to van Eijk (1997), the set of LRs includes voiced fricatives (*z' γ' ʕ' ʕ'ʷ*), which are unusual even within the Salish language family. Though not normally considered resonants, voiced fricatives are treated as resonants in St'át'imcets because, phonologically, they pattern with other resonants in terms of their distribution as well as in terms of having non-laryngealized counterparts (van Eijk 1997:4). More recently, Shahin (2002) has shown that, acoustically, the velar and uvular LRs are in fact better characterized as approximants, similar to the other LRs (leaving /z'/ as the exceptional laryngealized fricative).

3. Experiment. The goal of this experiment was to explore the realization of the laryngeal gesture in LRs. Of particular interest was the question of whether or not stress affected realization. Many Salishanists have noted that the timing of laryngealization is affected by stress. For example, according to Montler's (1986) description of SENĆOŦEN (Saanich; Central Salish) LRs, the laryngeal gesture is attracted to stress such that LRs are post-laryngealized preceding a stressed vowel ($R^{ʔ}\acute{v}$) and pre-laryngealized following a

[3] Van Eijk's phonetic alphabet (van Eijk 1997) is used here and elsewhere in this paper. For a conversion table between this alphabet, the IPA, and the St'át'imcets practical orthography, see Appendix A.

TABLE 1
St’át’imcets Consonant Inventory

Labial	Alveolar	Lateral	Palatal	Velar	Labio-velar	Uvular	Labio-uvular	Glottal
p	*t*			*k*	k^{w}	*q*	q^{w}	*ʔ*
p’				*k’*	$k^{’w}$	*q*	$q^{’w}$	
			c[1]					
	c’	*ƛ*						
		ɬ	*s*[1]	*x*	x^{w}	*x̌*	$x̌^{w}$	*h*
	z			*ɣ*		*ʕ*[2]	$ʕ^{w}$	
	z’			***ɣ’***		***ʕ’***	***ʕ’ʷ***	
m	*n*							
m’	***n’***							
			y		*w*			
			y’		***w’***			
		l[1]						
		l’[1]						

[1] These consonants also have retracted counterparts.
[2] The place of articulation of /ʕ ʕʷ ʕ’ ʕ’ʷ/across Salish languages is somewhat unclear. They are listed here with the uvulars based on van Eijk (1997) and Namdaran (2006). The symbols used, contradictory though they may seem (they are normally reserved for pharyngeals), are in keeping with standard phonetic descriptions of this and other Salish languages (see van Eijk 1997). For discussion of these sounds across Pacific Northwest languages, see Kinkade (1967), Shank and Wilson (2000), Carlson, Esling, and Harris (2004), and Shahin (2004; 2009).

stressed vowel (*v́ˀR*). Leslie (1979) describes the same pattern for the Cowichan dialect of Halkomelem (Central Salish). In the case of St’át’imcets itself, van Eijk (1997:11) describes the opposite pattern: “. . . the glottal stricture is strongest near the onset of the resonant before a stressed vowel but near the outset in other positions.” In contrast to these descriptions, previous acoustic analyses of LRs in Upper St’át’imcets have shown that timing is not affected by stress in any systematic way (Bird and Caldecott 2004 and Bird et al. 2008). Given that stress does play a role in the pronunciation (timing) of LRs in some Salish languages, the current study set out to determine whether stress could affect the realization of the laryngeal gesture in Upper St’át’imcets, even if it did not clearly affect its timing.

3.1. Methodology.

3.1.1. Data elicitation. The data for this study were collected in 2004 and are a subset of those used in two previous studies on the timing of St’át’imcets LRs, reported in Bird and Caldecott (2004) and Bird et al. (2008). In the current study, only words containing intervocalic LRs were considered. As mentioned above and contrary to van Eijk’s description, previous acoustic studies comparing timing across positions in Upper St’át’imcets have shown that LRs are pre-laryngealized in post-consonantal position (*VCˀRV*); post-laryngealized in pre-consonantal position (*VRˀCV*), and mid-laryngealized in

TABLE 2
DESCRIPTION OF TOKENS ELICITED IN THE STUDY OF LR REALIZATION

Context	Number of Tokens	Example Word (Orthography)	Example Word (van Eijk)	English Gloss
Pre-stress	42	*ci**m'**ín*	[xi**m'**ín]	to put something out of sight; to turn it low
Post-stress	42	*pú**l'**a*	[pú.**l'**a]	maggots (still in eggs)

TABLE 3
ELICITED TOKENS BY SPEAKER

Condition	CA	AP	LiR	Total
Pre-stress	16	16	10	42
Post-stress	10	13	19	42
Total	26	29	29	84

intervocalic position (*VR*^{ʔ}*RV*). The only exceptions to this pattern are /z'/ and /l'/, which are most often pre-laryngealized intervocalically, just as they are in post-consonantal position. In order to control as much as possible for timing, a single syllabic position was considered; intervocalic position was selected because it allowed for the straightforward comparison of pre- vs. post-stress environments (see table 2).[4]

Only /m' n' l' y' w' z'/ were included in this study; /ɣ'/ was excluded because of its rarity and /ʕ' ʕ'ʷ/ because they were most often pronounced without any acoustically observable oral gesture. A total of 36 words were taken from van Eijk's (1987) *Dictionary of the Lillooet Language*, each word containing a single LR that was used for analysis. Not all words were familiar to all speakers; as a result, each speaker produced a subset of the 36 words, leading to a total of 84 elicited tokens (see tables 2 and 3).

As table 2 illustrates, LRs either preceded the primary stressed vowel or followed it (LRs are in boldface). For the purposes of this study, stress placement was judged auditorily (i.e., based on perceptual auditory impressions) and verified through instrumental analysis in Praat (Boersma and Weenink 2006) by measuring pitch, amplitude, and duration.[5] This was a straightforward task, with the exception of four tokens, in which stress placement was unclear auditorily because of conflicting acoustic correlates (see Appendix

[4] It is assumed that intervocalic LRs are syllabified as onsets to the following syllable (V._V), although they are possibly better described as ambisyllabic (Marion Caldecott, personal communication).

[5] St'át'imcets speakers use a combination of pitch, amplitude, and duration to mark stress (Caldecott 2006; 2009).

B for details). In these cases, a second trained phonetician (also a St’át’imcets expert) was consulted, as an extra-cautionary measure. For three of the four tokens, both phoneticians agreed on stress placement; these tokens were therefore included in the analysis. The fourth token ([taw’an] spoken by CA) was excluded from analysis. In many of the words elicited, stress placement differed from that observed by van Eijk (1987) and analyzed in Roberts (1993) and Shaw (2009). This was particularly noticeable in words in the post-stress condition: nine of the 22 words used in post-stress condition had a different stress placement from that noted by van Eijk (see Appendix B for details). In all nine cases, primary stress was further left in the current study than in van Eijk (1987). This may be partly due to individual or dialectal differences: the three speakers whose speech forms the basis of the current study are different from those with whom van Eijk worked, and their speech patterns have therefore been influenced by different factors. It is also possible that a change is in progress in St’át’imcets with respect to stress placement, such that primary stress is moving further leftward in words. A systematic comparison between stress placement in van Eijk (1997) and that found in more recent studies would clarify the source of the observed discrepancies, which have also been noted by Caldecott in her doctoral research (Caldecott 2009).

Recordings were made with three fluent St’át’imcets speakers: Carl Alexander (CA): mid 60s, brother of Aggie Patrick, Upper St’át’imcets; Aggie Patrick (AP): early 60s, sister of Carl Alexander, Upper St’át’imcets; Linda Redan (LiR): mid 50s, Upper St’át’imcets with some Lower St’át’imcets influence (from mother). All three speakers use the language to communicate with family and elders in the community. Each word was checked with each speaker for familiarity. Words were then embedded in the frame sentence [cut s.darɪn __ ʔinatx^{w}as] ‘Daryn said __ yesterday’. The sentences were read by the speaker off of a laptop computer screen.[6] This method is not ideal for eliciting natural speech: frame sentences were held constant and, as a result, speakers could easily work out which word was targeted, leading to citation forms in production. Luckily, previous research has shown that the effects of different elicitation methods on speech patterns are minimal (Klatt 1976). Table 3 provides the breakdown of elicited tokens by speaker; see Appendix B for the details of which tokens were produced by which speaker.

Three recordings sessions, one with each speaker, were held in the kitchen of a private home in Lillooet, British Columbia, using a Sony MZ-B10 portable minidisc recorder and a Sony ECM-T115 lapel microphone. Sound files

[6] Speakers differed in their literacy levels. Because the frame sentence was kept constant, and because speakers were already familiar with the target words (from checking the word list), varying literacy levels did not pose a problem for the elicitation.

were then digitized using an iMac OSX and Sound Studio 2.07, and were analyzed on two Toshiba Satellite PCs using Praat version 4.1.13 (Boersma and Weenink 2006). It is important to note here that minidisc recorders are no longer recommended for recording speech because they compress the audio signal, leading to some loss of acoustic information. In a systematic study of various acoustic analyses across different kinds of compressed and decompressed sound files in Dutch, van Son (2002) showed that the compression system used in minidisc recordings (ATRAC) did not significantly distort either fundamental frequency or amplitude.[7] Since these measures formed the bulk of the acoustic analyses performed here, the recordings were not deemed problematic for the current study.[8] However, since a number of field recorders are now available which do not compress the audio signal at all, these should be used rather than minidisc recorders. Particularly in the case of highly endangered languages, where we may not have the opportunity to repeat recording sessions, it is essential to use equipment of the highest possible quality.

Of the 84 tokens elicited, 20 were discarded (14 in the pre-stress condition and six in the post-stress condition) due to unexpected pronunciations, including cases where no laryngealization was observed at all (ten cases in pre-stress condition and two cases in post-stress condition).[9] Appendix B provides further details of excluded tokens. Of the remaining 64 tokens, 36 were in the post-stress condition and 28 were in the pre-stress condition. Table 4 complements table 3 and provides a breakdown of analyzed tokens by speaker. As illustrated in table 4, LiR has only two pre-stress tokens (see also Appendix B). This is because LiR almost always neutralized the laryngeal contrast in this position, pronouncing it as a plain resonant (this point is discussed further in **4** below).

Table 5 provides a summary of the number of tokens analyzed by resonant. Note that the token counts are different across LRs, partly due to distributional

[7] ATRAC compression is based on psycho-acoustic models of human hearing, such that the acoustic information removed does not affect human perception of the acoustic signal. Because acoustic analysis is NOT based on psycho-acoustic models, compression may affect acoustic analysis, if not human audition. The algorithms used in compression are such that their effects on specific classes of sounds cannot be reliably predicted from the specifications of the algorithms, which is why some kinds of acoustic analysis of compressed sound files (e.g., the high-frequency spectral characteristics of fricatives) are not recommended (van Son 2002).

[8] Duration, which is also measured here, was not considered by van Son (2002), but a review of various discussion board posts as well as personal communications with a number of other linguists did not reveal any evidence that duration is distorted by ATRAC compression.

[9] The laryngealized–plain contrast is in the process of being neutralized in St'át'imcets such that, in a number of cases, what were expected to be laryngealized resonants based on the St'át'imcets orthography were pronounced as plain resonants. This has also been noted by van Eijk (1997:255) and Matthewson (2005:10).

TABLE 4
ANALYZED TOKENS BY SPEAKER

Condition	CA	AP	LiR	Total
Pre-stress	13	13	2	28
Post-stress	6	13	17	36
Total	19	26	19	64

TABLE 5
ANALYZED TOKENS BY LR

Condition	*l'*	*m'*	*n'*	*w'*	*y'*	*z'*	Total
Pre-stress	5	6	5	6	2	4	28
Post-stress	10	5	7	0	8	6	36
Total	15	11	12	6	10	10	64

facts. To include as many tokens as possible, uneven token counts across LRs and conditions were accepted.

3.1.2. Data analysis. Three trained phoneticians coded the data (see below for coding details): the first coded LRs in pre-stress condition, the second coded LRs in post-stress condition. The third coded all the data (in pre- and post-stress conditions) independently, as a way to ensure consistency in coding and to minimize the risk of measurement error. Cases of disagreement were flagged, and the third coder revisited these cases before assigning a definitive analysis to them.

All LRs were coded for the timing between the oral and laryngeal gestures as well as for the realization of the laryngeal gesture. Timing was coded in the way outlined in Bird and Caldecott (2004) and Bird et al. (2008), and was included simply to confirm previous results. The agreement rate between the current study and previous studies was 80% (51/64). This can be taken as an indication of the difficulty with which judgments were sometimes made. In all cases of disagreement, the LR was judged as mid-laryngealized in one case and something else in the other (pre- or post-laryngealized, or laryngealized throughout). Despite the 20% disagreement rate, the overall results of the current study replicated those of previous studies: intervocalically, /z'/ and /l'/ were pre-laryngealized in the majority of cases (70% and 67% of cases respectively; agreement rate with previous studies was 100% for /z'/ and 73% for /l'/); the other LRs were mid-laryngealized more often than not (56% of cases; agreement rate with previous studies was 77%). Since this paper focuses specifically on the realization of LRs, nothing more is said about timing.

In terms of realization, LRs were coded in two ways: auditorily and acoustically. Auditorily, LRs were coded as to whether or not they contained a complete glottal stop (e.g., /xim'in/→ [xiʔmin] vs. [xim̰in]). This was done auditorily because, as Pierrehumbert and Frisch (1996) point out, objective measures of what does vs. what does not constitute a glottal stop are very difficult to define.

Acoustically, LRs were measured in three ways, based on Gerfen and Baker (2004) and Hillenbrand and Houde (1996). First, the pitch perturbation caused by laryngealization was calculated by measuring the pitch at three points along the pitch contour (see figure 1): the pitch peak preceding laryngealization (F_{pk1}), the pitch valley during laryngealization (F_v), and the pitch peak following laryngealization (F_{pk2}).[10] Two different measures of pitch perturbation were calculated: (*i*) by subtracting the frequency of the pitch valley from that of the PRECEDING pitch peak ($F_{pk1} - F_v$) and (*ii*) by subtracting the frequency of the pitch valley from that of the FOLLOWING pitch peak ($F_{pk2} - F_v$). In both cases, pitch perturbation was calculated as a percentage reflecting the dip in pitch at the valley relative to the adjacent peak. The calculation used is provided in (1*a*) below.

Second, amplitude perturbation was measured in a way similar to pitch perturbation, but on the amplitude contour (see figure 1). Amplitude was measured at three points: the amplitude peak preceding laryngealization (A_{pk1}), the amplitude valley during laryngealization (A_v), and the amplitude peak following laryngealization (A_{pk2}). As with pitch, two different measures of amplitude perturbation were calculated: (*i*) by subtracting the amplitude of the valley from that of the PRECEDING peak ($A_{pk1} - A_v$) and (*ii*) by subtracting the amplitude of the valley from that of the FOLLOWING peak ($A_{pk2} - A_v$). As with pitch, amplitude perturbation was calculated as a percentage, as illustrated in (1*b*) below.

Third, the proportion of the LR that was laryngealized was calculated (including the glottal stop, if present, and any surrounding creakiness). This was done based on the spectrogram, using Praat's TextGrid tool to segment the sound files (see figure 1). The duration of the interval in which the pitch pulses were irregular and spread out relative to the adjacent sounds was measured, as well as the duration of the whole LR. Together, these measurements allowed for calculating the proportion of the LR that was laryngealized (see 1*c* below).

(1) Pitch, amplitude, and duration calculations

(1*a*) Pitch perturbation (%)

i. Relative to the preceding pitch peak = $(F_{pk1} - F_v)/F_{pk1} *100$

ii. Relative to the following pitch peak = $(F_{pk2} - F_v)/F_{pk2} *100$

[10] In some cases, pitch peaks were very far from the LR, in the adjacent vowel, but pitch platforms were observed in the modal portion of the resonant itself. In such cases, the pitch peak values used were those of the platforms within the resonant.

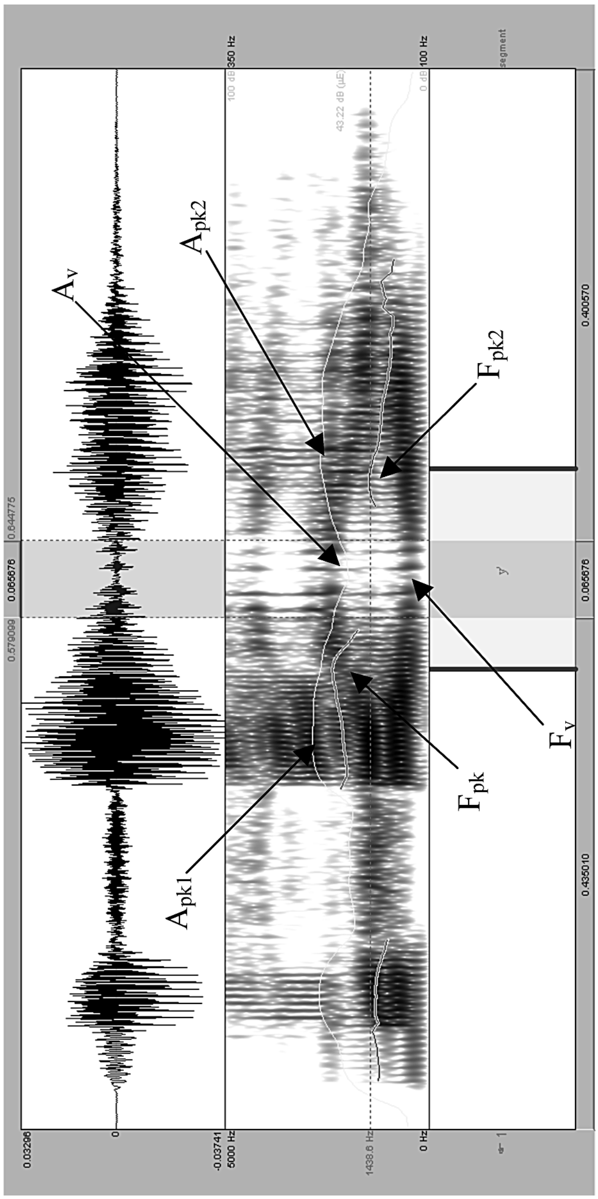

FIG. 1.—Spectrogram and waveform of [mexáy’a] ‘birch-bark basket’.

(1*b*) Amplitude perturbation (%)

i. Relative to the preceding amplitude peak = $(A_{pk1} - A_v)/A_{pk1} * 100$

ii. Relative to the following amplitude peak = $(A_{pk2} - A_v)/A_{pk2} * 100$

(1*c*) Proportion of laryngealization (%) = duration(laryngealization)/ duration(LR)*100

Figure 1 illustrates how measurements were taken in AP’s pronunciation of [mexáy’a] ‘birch-bark basket’, which was judged not to have a complete glottal stop. In cases such as this one, where the pitch contour was unreliable (disappeared) during laryngealization, manual measurements of the pitch valley were taken by zooming in on the waveform and measuring the duration of the single longest cycle. In figure 1, highlighting on the waveform and spectrogram indicates the laryngealized interval; highlighting on the text-grid below the spectrogram indicates the duration of the whole LR.

3.2. Results. The overall results show differences in the realization of the laryngeal gesture in pre- vs. post-stress position in all four measures: frequency of glottal closure, pitch and amplitude perturbations, and duration of laryngealization. More specifically, the acoustic correlates of laryngealization are all stronger in post-stress than in pre-stress position. However, many of these differences do not reach levels of significance. This is a result of two factors: high degrees of variability within the data and small sample sizes. As illustrated in table 6, the proportion of full stops is relatively variable across conditions. Similarly, standard deviations provided in tables 7 (pitch), 8 (amplitude), and 9 (duration) are relatively high. These reflect a substantial amount of variability within the data, a finding that is discussed further in **4** below.

The problem of small sample sizes has to do with limitations on data collection. First, LRs are relatively infrequent and, as discussed elsewhere in this paper, subject to neutralization with their plain counterparts such that the number of tokens available for analysis was limited. Second, few speakers remain with whom to work; consequently, the number of participants in the experiment was small. In addition, not all speakers were familiar with all words compiled for the experiment, and as a result each speaker only recorded a subset of the 36 words on the list. Third, some tokens had to be excluded from various analyses for technical reasons. For example, words with full glottal stops were excluded from the analyses of pitch and amplitude perturbation because the pitch and amplitude values during the stop reached zero and would therefore have skewed the perturbation values inappropriately. For all of these reasons, the number of tokens included in each analysis was relatively small, and consequently in most cases there may simply not have been enough power to reach significance.

Whether or not the lack of statistical significance has consistent and clearly identifiable sources, the reader should be alert to the fact that in many cases, results reflect tendencies rather than statistical certainties. Nonetheless, because all measurements point in the same direction (laryngealization is acoustically stronger in post-stress position), they are taken together as meaningful and reflective of a systematic effect of stress on the realization of the laryngeal gesture in LRs.

3.2.1. Presence vs. absence of glottal closure. Table 6 provides the number of tokens with and without a full glottal stop in pre-stress and post-stress positions. These results are based on auditory analysis because, as mentioned above, objective (acoustic) measures of presence vs. absence of glottal stop are very hard to define (Pierrehumbert and Frisch 1996). A post hoc comparison of the auditory and acoustic analyses for each token revealed that if the pause between any two glottal pulses exceeded approximately 30 ms, the token was judged auditorily to contain a complete stop. This duration is in the range provided by Pierrehumbert and Frisch (1996) in their study of English glottalization. The numbers in table 6 reflect the fact that a full stop is more likely to occur in post-stress position (e.g., [púl'a] 'maggots (still in eggs)') than in pre-stress position (e.g., [xim'ín] 'to put something out of sight'). Indeed, a full glottal stop was judged to occur in only 57% of LRs in pre-stress environments, compared to 72% of LRs in post-stress environments. Overall, this difference was not statistically significant; it was particularly noticeable, however, in LiR's speech, who also neutralized the plain ~ laryngeal contrast the most consistently, leading to very few tokens in pre-stress position (see table 4 above). These two facts are likely related, the loss of a complete closure perhaps acting as a precursor to the complete loss of laryngealization. This issue is discussed further in **4** below.

That full glottal stops are more common in post-stress position is a first indication that the acoustic correlates of laryngealization tend to be stronger in this position, at least under the assumption that a complete stop is a more dramatic interruption of the otherwise modal acoustic signal than is creakiness.[11] This tendency is further supported by the acoustic data on pitch and amplitude perturbation, as well as that on the duration of laryngealization, as discussed below.

3.2.2. Pitch. Table 7 provides the mean pitch perturbations in pre-stress vs. post-stress positions, as percentages of the pitch of adjacent peaks (see 1*a*

[11] Note that the term "correlate" is used throughout the paper rather than "cue," to avoid making any assumptions about the perceptual consequence of the acoustic patterns observed here. The question of how acoustic information is perceived is a fascinating one, and one that will be addressed by future studies on the perception of LRs.

TABLE 6
INSTANCES OF FULL GLOTTAL STOP ACROSS STRESS CONDITIONS AND SPEAKERS

Condition	CA	AP	LiR	Total across Speakers
Pre-stress	11/13 (85%)	4/13 (31%)	1/2 (50%)	16/28 (57%)
Post-stress	5/6 (83%)	6/13 (46%)	15/17 (88%)	26/36 (72%)

TABLE 7
PITCH PERTURBATION ASSOCIATED
WITH LARYNGEALIZATION IN PRE- AND POST-STRESS CONDITIONS

Condition	Number of Tokens	Mean Perturbation % (SD)
Pre-stress (relative to preceding peak)	10	43.7 (27.7)
Pre-stress (relative to following peak)	10	48.6 (28.1)
Pre-stress: average F perturbation	**10**	**46.1 (27.8)**
Post-stress (relative to preceding peak)	8	72.2 (14.3)
Post-stress (relative to following peak)	8	67.1 (16.3)
Post-stress: average F perturbation	**8**	**69.7 (15.2)**

above). The higher the percentage, the larger the pitch perturbation (dip) associated with laryngealization. Results from /z'/ are excluded from table 7. This segment was devoiced and usually preceded by a full closure: [ʔz̥]. Because /z'/ was devoiced, the pitch peak following the glottal stop did not occur until after the fricative, during the following vowel. As such, it was not clearly representative of the pitch perturbation associated specifically with laryngealization, which preceded the fricative. In addition, results presented in table 7 are based only on cases without a full glottal stop since in cases with glottal stop, the pitch drops so low that it is no longer considered a pitch perturbation, but rather a complete cessation of voicing (and hence loss of pitch).

Standard deviations for the percentages reported in table 7 are relatively high, indicating a substantial amount of variability (mentioned above) within the data. If we compare first the two perturbation measures in pre-stress position, the mean perturbation relative to the preceding peak is smaller than it is relative to the following peak: 43.7% vs. 48.6%. Stress is marked in part by raised pitch in St'át'imcets, such that the stressed vowel has a higher pitch than the unstressed vowel. In pre-stress position, the LR is preceded by an unstressed vowel and followed by a stressed vowel. This leads to a lower frequency peak preceding laryngealization than following it, which explains why the pitch perturbation is smaller relative to the preceding peak than relative to the following peak. Conversely, in post-stress position, the mean perturbation is smaller relative to the following peak than it is relative to the preceding peak: 67.1% vs. 72.2%. Again, this pattern can be explained by the stress facts: in this case, the LR is preceded by a stressed vowel and followed by an unstressed vowel. As a result, there is a higher frequency peak preceding laryngealization than following it, which explains why the pitch perturbation is greater relative to the preceding peak than relative to the following peak.

To test for a statistically significant effect of stress on pitch, the average pitch perturbation (merging perturbations relative to preceding and following peaks) was compared in pre-stress vs. post-stress conditions (see rows in boldface in table 7). As explained in the preceding paragraph, the biggest perturbation in pre-stress condition was found relative to the following peak and the biggest perturbation in post-stress condition was found relative to the preceding peak. By comparing average pitch perturbations, these asymmetries in pitch perturbation values were avoided. An independent samples *t*-test revealed that pitch perturbations in post-stress condition were significantly larger than those in pre-stress condition ($t(16) = 2.143$; $p < 0.05$).

3.2.3. Amplitude. Table 8 is similar to table 7 but provides measurements of amplitude perturbation rather than pitch perturbation. Again, the higher the percentage, the larger the amplitude perturbation (dip) associated with laryngealization. Tokens with /z'/ are excluded, as are tokens with a full glottal stop, in which the amplitude valley effectively drops to zero.

The results for amplitude are not quite as clear as they are for pitch. Standard deviations are again relatively high, reflecting high degrees of variability within the data. In post-stress position, results are as expected: the mean perturbation relative to the preceding peak is greater than the perturbation relative to the following peak, reflecting the fact that the preceding vowel is stressed and hence higher in amplitude than the following unstressed vowel. However, this pattern does not hold in pre-stress position. One would expect the mean perturbation relative to the following peak to be greater than the mean perturbation relative to the preceding peak, but this is in fact not the case. These results may reflect the fact that in St'át'imcets, amplitude is a less reliable correlate of word-level stress than is frequency. This could be tested with a perception study, in which pitch and amplitude were manipulated independently from one another to see which correlate had the greatest effect on listener's perception of stress. The results may also be an effect of the sound compression inherent to minidisc recordings; as mentioned above, it is impossible to ascertain for certain what the effect of compression is on amplitude.

To test for a statistically significant effect of stress on amplitude, the average amplitude perturbation (merging perturbations relative to preceding and following peaks) was compared in pre-stress vs. post-stress conditions (see boldface rows in table 8). An independent samples t-test revealed that

TABLE 8
AMPLITUDE PERTURBATION ASSOCIATED WITH LARYNGEALIZATION IN PRE- AND POST-STRESS CONDITIONS

Condition	Number of Tokens	Mean Perturbation % (SD)
Pre-stress (relative to preceding peak)	10	22.7 (9.7)
Pre-stress (relative to following peak)	10	21.1 (12.9)
Pre-stress: average A perturbation	**10**	**21.9 (11.1)**
Post-stress (relative to preceding peak)	8	29.6 (6.8)
Post-stress (relative to following peak)	8	24.3 (6.0)
Pre-stress: average A perturbation	**8**	**26.9 (5.9)**

TABLE 9
DURATION OF LARYNGEALIZATION IN PRE- AND POST-STRESS POSITIONS

Condition	Number of Tokens	Mean (SD)
Pre-stress: whole LR duration (ms)	9	152 (21)
Pre-stress: laryngealization duration (ms)	9	71 (32)
Pre-stress: % laryngealization (%)	**9**	**46 (20)**
Post-stress: whole LR duration (ms)	8	161 (28)
Post-stress: laryngealization duration (ms)	8	97 (39)
Post-stress: % laryngealization (%)	**8**	**59 (14)**

pitch perturbations in pre-stress and post-stress conditions were not significantly different from one another. However, the direction is the same as that for pitch: amplitude perturbations tended to be greater in post-stress than in pre-stress position.

3.2.4. Duration. Table 9 provides the mean durations of LRs, of the laryngealized portion of LRs, and of the proportion of the whole LR that is laryngealized (based on the durational measurements—see 1*c* above for calculation). Note that the laryngealized portion of the LR did not necessarily appear exclusively on the resonant itself: in some cases, laryngealization was observed on the surrounding vowels, either as well as or instead of on the resonant. Cases in which there were no observable pitch irregularities were excluded, i.e., cases in which laryngealization was associated solely with a modal perturbation in pitch.[12] In addition, /z'/ tokens were excluded, as were cases with a complete glottal stop. Since many more cases of complete glottal stop were observed in post-stress than in pre-stress position (see table 6), only cases without a complete glottal stop were considered to avoid confounding the effects of stress position and presence of a glottal gesture.

[12] There was in fact only one token which exhibited a lowered pitch without any accompanying irregularity in the pitch pulses.

Similarly to pitch and amplitude measures, a fair amount of variability was observed with respect to duration, as illustrated by the relatively high standard deviations reported in table 9. Despite this, the mean durations of LRs and of their laryngealized portions are longer in post-stress position (161 ms and 97 ms respectively) than in pre-stress position (152 ms and 71 ms respectively). In addition, the mean proportion of the LR that is laryngealized is greater in post-stress position than in pre-stress position (46.2% vs. 59.4%). These differences are not statistically significant, but they too are in the same direction as pitch and amplitude perturbations discussed previously.

To summarize the results, a substantial amount of variability was found within the data, for all of the measurements taken. Abstracting away from this, we can say that post-stress position was associated with a higher number of complete glottal stops, more pronounced pitch and amplitude perturbations, and longer durations of the laryngeal gesture, both absolute and relative to the duration of the LR. Although the only effect that was statistically significant was that of stress position on pitch perturbation, the strong agreement across measurements is taken to reflect the fact that, overall, the acoustic correlates of laryngealization are stronger in post-stress than in pre-stress position. The St'át'imcets data therefore indicate that prosodic structure affects the realization of laryngeal gestures, a fact that was noted as far back as Verner (1875) in his exploration of exceptions to the first sound shift (Lehmann 1967).

4. Discussion. The first finding worth discussing—particularly because of its effect on statistical significance—is the high degree of variability observed throughout the data. This variability has two potential sources. First, it is possible that LRs are simply underspecified in terms of laryngealization, in the sense of Steriade (1995). This makes sense from a functional perspective: St'át'imcets contrasts plain vs. laryngealized resonants, but there are no contrasts within the laryngealized set. In fact, no languages have been identified that systematically and productively contrast different implementations of laryngealization, for example, pre- vs. post-laryngealization.[13] It is plausible that the only requirement in terms of phonetic implementation is that LRs be perceptually distinct from their plain counterparts, with the details of how this is done left unspecified and therefore subject to variability.[14] The second possible source of variability is language attrition. Dorian (1981) has noted that language attrition is associated with increased variability at all levels of linguistic structure, including the phonetic implementation of

[13] It has been argued that Hupa contrasts pre- and post-laryngealization in a restricted set of forms. See Golla (1977) and Gordon (1996) for details.

[14] For further support for the idea of underspecified laryngealized resonants, see Kingston (1984; 1990) on timing of laryngeal gestures in obstruents vs. resonants.

sounds. It is likely that both underspecification and language attrition play a role in generating the observed variability in St'át'imcets LRs. To the extent that underspecification is involved, however, no amount of additional data would change the size of the effects, in other words create significance where none was observed.

When we abstract away from the observed variability, the results indicate that the correlates of laryngealization were stronger in post-stress than in pre-stress position. Why would this be the case? One thing to note about stress position is that it corresponds to syllable position. In pre-stress position, the LR belongs to the same syllable as the stressed vowel, as in [xi.**m'**ín]. In post-stress position, the LR belongs to the following syllable, as in [pú.**l'**a]. Perhaps a better way of thinking about the differences in LR realization is in terms of whether or not the LR falls within the stressed syllable: LRs within the stressed syllable (pre-stress) are pronounced with lesser degrees of laryngealization than LRs outside of the stressed syllable (post-stress). Stress in St'át'imcets is marked by a combination of raised pitch, higher amplitude, and longer duration (Caldecott 2006), the first two correlates being in direct conflict with those of laryngealization. It is therefore possible that when stress and laryngealization occur within a single syllable, stress "wins"; in other words, the acoustic correlates of laryngealization in this position remain weak so as not to compromise the perceptual salience of stress. The shorter duration of laryngealization in pre-stress position may also be accounted for in reference to stress. A shorter laryngealized interval entails shorter pitch and amplitude perturbations, which presumably conflict less with the correlates of stress than the longer perturbations found in post-stress position.

While the conflicting correlates of stress vs. laryngealization may partially account for the observed properties, they cannot wholly account for them. Recall that post-stress LRs are also associated with more instances of complete glottal stop than are pre-stress LRs. Presence of a complete glottal stop does not clearly conflict with the correlates of stress, since glottal stop is not necessarily associated with lowered amplitude or pitch (Edmondson and Esling 2006). If the laryngealization facts were solely a function of conflicting correlates, one would not expect more instances of glottal stop in post-stress than in pre-stress position. The fact that the asymmetrical realization of laryngealization across stress positions is relatively robust across all acoustic correlates suggests that something more is involved, though what that might be remains for the time being a mystery.[15]

[15] One possibility is that the asymmetry started out as a purely phonetically motivated effect (affecting pitch, duration, and amplitude) and was only later phonologized, at which point the proportion of full stops also became involved.

Whatever the reason for the differences in the realization of LRs in pre- vs. post-stress position, it seems that the strength of the acoustic correlates of laryngealization is directly correlated with the neutralization facts of the language. Recall from **2** above that neutralization of the laryngeal contrast seems to be most prevalent in pre-stress position, leading to fewer tokens analyzed in this position than in post-stress position (see tables 4 and 5). In particular, LiR only has two pre-stress tokens (see table 4). In all other pre-stress tokens, she pronounces the LR as its plain counterpart. This asymmetry in terms of where neutralization occurs matches the acoustic results presented in **3**: pre-stress position involves the weakest correlates of laryngealization and is also the position in which neutralization occurs the most frequently. It is not clear whether a causal relationship can be established here. Are weaker acoustic correlates in pre-stress position leading to positional neutralization? Or is positional neutralization (as a change in progress) leading to weaker acoustic correlates in pre-stress position, as a precursor to complete loss of these correlates? According to researchers such as Silverman (1997) and Steriade (1997), the former should be true: positional neutralization results from the lack of perceptually salient acoustic correlates. However, it seems possible that neutralization (triggered by some other factor) causes weaker acoustic correlates in the neutralizing position, correlates which will eventually disappear altogether. Teasing these two causal relationships apart requires further study of a wide range of facts across languages.

The finding that stress seems to play a role in the realization of the laryngeal gesture in St'át'imcets LRs is particularly interesting given previous findings on the timing of laryngealization in St'át'imcets. As noted at the beginning of **3** above, many linguists have observed that in Salish languages, timing of laryngealization is affected by stress, e.g., Leslie (1979) on the Cowichan dialect of Halkomelem (Central Salish) and Montler (1986) on SENĆOŦEN (Saanich; Central Salish). In his exposition of St'át'imcets itself (Lower dialect), van Eijk notes ". . . the glottal stricture is strongest near the onset of the resonant before a stressed vowel but near the outset in other positions" (1997:11). However, in contrast to these descriptions, more recent instrumental studies have shown that stress does not play a systematic role in the timing of the laryngeal gesture with respect to the oral one(s), at least in Upper St'át'imcets (Bird and Caldecott 2004 and Bird et al. 2008). Together, the current experiment on the realization of LRs combined with previous instrumental studies on their timing (Bird and Caldecott 2004 and Bird et al. 2008) suggests that the factors influencing timing can be independent from those influencing realization, which implies that the pronunciation of these sounds results from a complex interaction of several factors.

How and to what extent are these factors encoded in the lexical representation of LRs? It has recently been argued (Cutler and Weber 2007, Goldinger 2007, McLennan 2007, and others) that the lexical representation of sounds consists of two kinds of information, abstract and episodic, and that a hybrid approach to lexical representation which includes both kinds of information, such as Goldinger’s (2007) Complementary Learning Systems (CLS) approach, will prove the most successful at modeling this representation. In the case of LRs, the abstract component of the lexical representation would include a relatively vague laryngeal specification (in featural terms [+constricted glottis], for example), thus allowing for the observed variability in its realization; the episodic component would include information on timing and realization, as a function of linguistic factors such as stress, syllabic position, the resonant involved, and possibly also as a function of social factors such as speaker, dialect, and register. The precise way in which abstract and episodic information is unified in a single lexical representation is still a question of much debate (see Cutler and Weber 2007, Goldinger 2007, McLennan 2007, and others) but promises to lead phonological theory in new and exciting directions.

5. Conclusion. While many researchers have investigated LRs from the perspective of articulatory timing, very few have focused on the realization of the laryngeal gesture in these sounds. The study presented above fills this gap, by considering the realization of St’át’imcets LRs. Results show that despite substantial variability, the acoustic correlates of laryngealization tend to be stronger in post-stress than in pre-stress position. The effect of stress on the realization of LRs is surprising given that, unlike in some other Salish languages (e.g., SENĆOŦEN), stress has been shown not to affect the timing of the laryngeal gesture with respect to the oral one(s) in St’át’imcets, at least in recent studies based on instrumental analysis. Why this asymmetry in the strength of the acoustic correlates of laryngealization in pre- vs. post-stress positions occurs, and whether it is the cause of positional neutralization of the St’át’imcets laryngeal contrast is a matter that will be addressed in future research, in part through complementary perceptual studies of these sounds.

Whatever the precise relationship between stress and laryngealization in St’át’imcets, an interesting issue raised by this project is the inconsistent location of word stress across speakers, as evidenced by differences between the current study and van Eijk’s (1997) observations. This issue needs further exploration, in particular to determine how robust a phenomenon stress is in the language, and how it might interact with higher-level prosodic phenomena (on this topic, see Caldecott 2009).

Finally, it is worth repeating here how important it is, particularly in working with highly endangered languages like St’át’imcets, to use equipment that produces recordings of the highest possible quality. Some of the inconsistency in the results reported here may have been due to the compression inherent to minidisc recorders—it is simply impossible to tell for certain.

Given the current availability of relatively inexpensive field recorders that offer high-quality (and uncompressed) recordings from manufacturers such as M-Audio, Marantz, Zoom, and others, there is no longer a need to use minidisc recorders in linguistic fieldwork.

APPENDIX A

Orthographic Conversions

Throughout the paper, van Eijk's phonetic alphabet is used. Table 10 provides a conversion between van Eijk's alphabet, the St'át'imcets practical orthography, and the International Phonetic Alphabet.

TABLE 10
Symbol Conversion Chart for Upper St'Át'imcets

Practical Orthography	van Eijk (1997)	IPA (NAPA)	Practical Orthography	van Eijk (1997)	IPA (NAPA)
a	a	[æ]	c	x	[x]
ao	a̲	[ɑ]	cw	xʷ	[xʷ]
e	ə	[ə]	x	x̌	[χ]
v	ə̲	[ʌ]	xw	x̌ʷ	[χʷ]
i	i	[i]	m	m	[m]
ii	i̲	[ɛ]	n	n	[n]
u	u	[u]	m'	m'	[m']
o	u̲	[ɔ]	n'	n'	[n']
p	p	[p]	l	l	[l]
t	t	[t̪]	l̲	l̲	[ḷ]
ts	c	[tʃ] ([č])	l'	l'	[l']
t̲s̲	c̲	[tṣ]	l̲'	l̲'	[ḷ']
k	k	[k]	z	z	[z]
kw	kʷ	[kʷ]	y	y	[j] ([y])
q	q	[q]	r	ɣ	[ɣ]
qw	qʷ	[qʷ]	g	ʕ	[ʕ]
p'	p'	[p']	gw	ʕʷ	[ʕʷ]
t'	ƛ	[tɬ'] ([ƛ])	h	h	[h]
ts'	c'	[ts']	w	w	[w]
k'	k	[k']	z'	z'	[z']
k'w	kʷ	[k'ʷ]	y'	y'	[j'] ([y'])
q'	q	[q']	r'	ɣ'	[ɣ']
q'w	q'ʷ	[q'ʷ]	g'	ʕ'	[ʕ']
lh	ɬ	[ɬ]	gw'	ʕ'ʷ	[ʕ'ʷ]
s	s	[ʃ] ([š])	7	ʔ	[ʔ]
s̲	s̲	[ṣ]	w'	w'	[w']

This chart is based on Namdaran (2006:162). The four orthographies presented here are:

(1) Practical Orthography: most familiar to St'át'imcets speakers
(2) van Eijk's Phonetic Alphabet: used in van Eijk (1997) and Matthewson (2005)
(3) IPA (International Phonetic Alphabet): standard in the field of phonetics
(4) NAPA (North America Phonetic Alphabet): most familiar to Salishanists

Note that in his phonetic alphabet, van Eijk (1997) uses a dot rather than an underline on retracted sounds; an underline is used here for ease of transcription, and in agreement with Matthewson (2005).

APPENDIX B

Word Lists Used

In tables 11–14, the laryngealized resonant of interest is in boldface. The "Practical Orthography" column includes information on the source of the word: the page number if the word came from van Eijk (1987) or the name of the speaker who provided the form. The * indicates cases where stress differs from that listed in van Eijk (1987). For all cases of disagreement with van Eijk (1987), the location of stress in the current data was verified through acoustic analysis: the vowel judged auditorily to be stressed consistently exhibited raised pitch (relative to the unstressed vowel[s] in the word), as well as raised amplitude in all cases but one, [k'em'én] (AP). This token was one of four that proved problematic in terms of stress assignment. The other three were: [taw'án] (CA), which had raised pitch on the first syllable but much longer duration on the second, and [texay'úsen] (LR; CA), which had slightly raised pitch on [a] but longer duration on [u]. For these four tokens, a second trained phonetician was asked to judge stress placement as well, as an extra-cautionary measure. In the end, only one token was actually excluded from analysis because of unclear stress placement: [taw'án] (CA). The "Tokens" column is used to keep track of which speaker(s) provided the token; parentheses around the speaker's initials indicate that the token was discarded.

TABLE 11
Words Used in Post-Stress Condition

Practical Orthography	van Eijk Phonetic Alphabet	Gloss	Tokens
*caqwá**n'**asú7* (CA)	[xaqʷá**n'**ásƛ̓uʔ]	to clear something out (e.g., snow on a trail)	CA
*cwá**z'**an* (203)*	[xʷá**z'**an]	to forget about something	LiR
*k'é**m'**en* (166)	[k'ə́**m'**ən]	to put something in a narrow split or crack, to plug something in	LiR
*kací**m'**a* (191)	[kaxí**m'**a]	to disappear temporarily	AP CA LiR
*ki mecá**z'**a* (52)	[ki məxá**z'**a]	the huckleberries	AP
*mecá**y'**a* (52)	[mexá**y'**a]	birch-bark basket (for carrying water)	AP (CA) LiR
*n'á**n'**atcwam* (112)*	[n'á**n'**atxʷam]	to do something in the morning; to get up early to do something	LiR × 2
*nq'p'á**m'**us* (220)	[nq'p'á**m'**us]	to lie on one's belly	LiR
*p'á**n'**an* (42)*	[p'á**n̓**an]	to bend something	AP LiR
*p'á**n'**anlhkan* (42)*	[p'á**n'**anɬkan]	I bent it	AP LiR
*pep7ú**y'**acw* (41)*	[pəpˀú**y'**axʷ]	little mouse	(CA)
*pú**l'**a* (33)	[pú**l'**a]	maggots (still in eggs)	AP CA LiR
*qú**l'**el'* (236)	[qʷú**l'**əl']	cloudy	AP (CA) LiR
*sá**l'**is* (101)*	[sá**l'**is]	hardest type of rock (flint)	AP LiR
*sawí**n'**en* (108)	[sawí**n'**ən]	to question, interrogate someone	(LiR)
*sí**l'**us* (CA; LiR; AP)	[sí**l'**us]	you had time to do something	AP CA LiR

TABLE 11—*continued*

Practical Orthography	van Eijk Phonetic Alphabet	Gloss	Tokens
t'áy'en (132)	[ƛá**y'**ən]	to imitate someone	AP CA LiR
t'úl'un (126)*	[ƛú**l'**un]	to calm things down	(LiR)
tacwáy'a (60)	[tax^{w}á**y'**a]	to wrestle	AP CA LiR
tsq'áz'a (229)	[cq'á**z'**a]	the roof	AP (CA) LiR
tsqáz'am (75)	[cqá**z'**am]	to store away barbecued salmon	AP LiR

Total number of post-stress tokens: 42 (elicited) – 6 (discarded) = 36 (analyzed)

TABLE 12
TOKENS DISCARDED IN POST-STRESS CONDITION

Token	Reason
[mexá**y'**a] (CA)	No laryngealization
[pəpˀú**y'**ax^{w}] (CA)	Unexpected pronunciation: [pəpú**y**aˀx^{w}]
[q^{w}ú**l'**əl'] (CA)	Technical difficulty: boundary between [ú] and [l'] unclear, making measurements problematic; second vowel missing (syllabic [l'])
[sawí**n'**ən] (LiR)	Whole token pronounced with a lot of creak; no laryngealization clearly associated with [n']
[ƛú**l'**un] (LiR)	No laryngealization
[cq'á**z'**a] (CA)	Unexpected pronunciation: extremely long glottal closure (610 ms), followed by what sounds like [l] rather than [z]: [cq'aˀ:la]

TABLE 13
WORDS USED IN PRE-STRESS CONDITION

Practical Orthography	van Eijk Phonetic Alphabet	Gloss	Tokens
*ci**m'**ín* (191)	[xi**m'**ín]	to put something out of sight, to turn it low	AP
*cwa**z'**án* (203)	[x^{w}a**z'**án]	to forget about something	AP CA
*k'e**m'**én* (166)*	[k'ə**m̓**ə́n]	to put something in a narrow split or crack, to plug something in	AP
*ku**l'**ún* (181)	[k^{w}u**l'**ún]	to soak something	AP CA LiR
*ma**z'**ús*	[ma**z'**ús]	bow on baby basket (keeps blanket away from baby's face)	(LiR) (CA)
*ncwu**z'**ún* (204)	[nx^{w}u**z'**ún]	to take things out of a box, drawer	AP CA (LiR)
*nsupa**n'**ákem* (96)	[nsupa**n'**ákəm]	to scratch one's belly	(AP)
*nsupki**n'**úsem* (96)	[nsupki**n'**úsəm]	to scratch one's forehead	AP CA
*nteqki**n'**úsem* (61)	[ntəqki**n'**úsəm]	to cross oneself, make the sign of the cross	AP CA
*p'a**n'**ánlhkan* (42)	[p'a**n'**ánɬkan]	I bent it	CA
*sa**l'**ís* (101)	[sa**l'**ís]	hardest type of rock (flint)	(CA)

TABLE 13—*continued*

Practical Orthography	van Eijk Phonetic Alphabet	Gloss	Tokens
taw'án (64)	[taw'án]	to ruin something (e.g., by dropping it or getting it dirty)	AP (LiR) (CA)
texay'úsen (60)	[təx̌ay'úsən]	to try and beat someone at an argument	(AP) CA LiR
t'enam'ílc (123)	[ƛ̓ənam'ílx]	to try	AP CA (LiR)
tsal'álh (71)	[tsal'áɬ]	lake	AP
ts'am'án (81)	[c'am'án]	to lick something	AP CA (LiR)
ts'aw'ák7am (93)	[c'aw'ákˀam]	to wash one's hands	(AP) CA (LiR)
ts'aw'án (93)	[c'aw'án]	to wash something	AP CA (LiR)
ts'aw'úsem (93)	[c'aw'úsəm]	to wash one's face	AP CA (LiR)
t'ul'ún (126)	[ƛ̓ul'ún]	to calm things down	CA

Total number of post-stress tokens: 42 (elicited) – 14 (discarded) = 28 (analyzed)

TABLE 14
DISCARDED TOKENS IN PRE-STRESS CONDITION

Token	Reason
[ma**z'**ús] (CA)	No laryngealization
[ma**z'**ús] (LiR)	Whole token pronounced with a lot of creak; unclear to what extent laryngealization is associated with [z'] vs. with overall pronunciation
[nxʷu**z'**ún] (LiR)	No laryngealization
[nsupa**n'**ákəm] (AP)	No laryngealization
[sa**l'**ís] (CA)	Unexpected pronunciation: no clear [l'] (sounds like [saˀís])
[ta**w'**án] (CA)	Stress unclear (conflicting cues: according to pitch: [táw'an]; according to duration: [taw'án])
[ta**w'**án] (LiR)	No laryngealization
[təx̌a**y'**úsən] (AP)	Unexpected pronunciation: extremely long glottal closure (534 ms) (spoken as two separate words: [təx̌ay'] and [yúsən])
[ƛ̓əna**m'**ílx] (LiR)	No laryngealization
[c'a**m'**án] (LiR)	No laryngealization
[c'a**w'**ákˀam] (AP)	No laryngealization
[c'a**w'**ákˀam] (LiR)	No laryngealization
[c'a**w'**án] (LiR)	No laryngealization
[c'a**w'**úsəm] (LiR)	No laryngealization

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