Lushootseed Vowels - A preliminary phonetic study

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1.0 Introduction

This paper presents an acoustic analysis of Lushootseed vowels, based on data from two stories, "Pheasant and Raven" and "Mink and Tetyika," told by Martha Lamont to Thom Hess. This paper will focus on two phonetic properties of vowels, namely, duration and quality. I will show that duration of the stressed and unstressed vowels exhibit consistent length with respect to one another. While stressed vowels are always longer than their unstressed counterparts, /a/ is consistently the longest vowel and /ə/ is consistently the shortest. I will also show that stressed vowels are maximally distinct from one another in the vowel space. Unstressed vowels, although they do centralize, maintain some distinctive vowel space and do not simply collapse to "schwa."

2.0 Background

Most of the Salish literature in which schwa is discussed, views schwa as a predictable placeless vowel whose quality is determined by its context. These studies are mostly phonological and highly theoretical. Previous works include: Bates, (1986), Beck (1995), Bianco (1995, 1996), Czaykowska-Higgins (1993), Kinkade (1993, 1997), Matthewson (1994), Willett and Czaykowska-Higgins (1995), and Urbanczyk (1996). In these accounts it seems there is much agreement that schwa is a predictable vowel inserted when necessary for syllable structure, reduplication, or stress assignment. Kinkade (1993) proposes that schwas are never present in underlying forms of any Salish language. Following Levin (1987), he maintains that schwa is explainable through one of four processes: excrescence, epenthesis, derivation from a nasal consonant or reduction from a full vowel. Excrescent schwas are phonetic transitional vowels usually associated with resonants. These schwas are often influenced by surrounding consonants. Epenthetic schwa is closer to a full vowel and may be present at the phonological level in that it contrasts with full vowels and can be stressed. Different languages treat epenthetic schwa differently. In some languages this schwa cannot take stress and at least in Bella Coola it is not present at all. Derived schwa is a "marginal schwa," in that it has only been shown to exist in Moses-Columbia Salish. Apparently an underlying /m/ surfaces as schwa in inter-consonantal environments. Reduced schwas are underlying full vowels that surface as schwa due to lack of stress. By far, epenthetic schwa has received the greatest amount of attention in the literature.

Phonetic studies of Salish languages are much less numerous. Flemming, Ladefoged and Thomason provide a brief look at the vowels of Montana Salish. They describe the

formant structures of /i, e, a, o, u/ and discuss intrinsic pitch, but avoid vowel duration because of limitations of their data set. The bulk of their paper, however, is devoted to the discussion of consonants. Johnson and Ladefoged conducted a perceptual study of Montana Salish where speakers were asked to identify synthetic speech sounds that most closely match particular vowels in the language. The largest body of phonetic work on Salish languages comes from Bessell (1992, 1993, 1997). Her work mainly involves the interaction of vowels and consonants, and the influence of consonants on vowels, especially post-velars. She draws heavily on her phonetic experience to inform her phonological study. Beck (1995) follows in this line by first establishing a phonetic definition for secondary stress in Lushootseed and then accounts for it in Optimality Theory.

3.0 The Analysis

For this paper, I digitized naturally occurring narrative data in order to be able to analyze the vowels using spectrograms and wave forms. Given the nature of the recordings, the data are less than optimal for phonetic analysis, and yet are free from certain pitfalls of data collected and analyzed in the phonetics lab. On the other hand, one particular advantage is that these data are not prone to "undo reduction processes," which would be problematic for a study of schwa.[1]

3.1 Data

The data for this study come from two narratives told by Martha Lamont in the early 1960s. The recordings were made on a reel to reel tape recorder by Thom Hess. The copy that I have is a cassette tape, which means it is at least a second generation from the original. As a result there is considerable background noise. There are also noises in the background which include a closing door, a dog and a rocking chair that apparently the speaker was sitting in.

Because of this, it was necessary to constrain the data by selecting tokens that maximize the true nature of the vowels and minimize contextual influences. Simplicity was of primary importance in the selection process. I chose the least complex forms I could. The optimal form was a root without affixes that appeared to be categorized as a noun, e.g. *bəščəb* 'mink.'[2] Elsewhere, I was forced to choose forms with affixes, but I selected the simplest forms possible. I avoided forms with glottalization in the immediate consonantal environment. I did not analyze diphthongs. Table 1 below shows the list of forms selected from the narratives.

[1] Johnson and Ladefoged, 1994:105.

[2] In Salish there is much debate about whether noun and verb are appropriate categories for the languages. One proposal suggests that predicate and particles are more reasonable categories. For the purposes of my paper, I consider nouns to be what seems to function as arguments and verbs to be what appears to have predicative force.

		a	i	u	ə
monosyllabic		sqas 'older sibling'		skʷup 'sucker fish'	bəlkʷ 'return'
Same		qaha 'brother'		cutcut 'say'	bəščəb 'mink'
Labial	**stressed**	sˀušəbábdxʷ 'poor thing'	qʷibyitəbəxʷ	sgʷəlub 'pheasant'	xʷəbtəb 'throw'
	unstressed	kʷásabacəxʷ 'roasted body'	dukʷibəɬ 'changer'		sqʷəbay 'dog'
Alveolar	**stressed**	tátačulbixʷ 'large animal'	ˀix̌ʷitəbəxʷ 'throw away'		xʷədtəbəxʷ 'shove'
	unstressed	Sqígʷac 'mule deer'	x̌iditəbəxʷ 'growl'		bədaˀ 'child'
Velar	**stressed**	kʷágʷičəd 'elk'	sqígʷac 'mule deer'	dukʷibəɬ 'changer'	ləgʷləgʷəb 'youths'
	unstressed				čəgʷas 'wife'
Liquid	**stressed**	ɬáliləxʷ 'go ashore'	gʷədil 'sit'		
	unstressed	ˀaciɬtalbixʷ 'people'	ɬáɬlil 'live'	tátačulbixʷ 'large animal'	sgʷəlub 'pheasant'

Table 1 Lushootseed forms in Data Sample

This table shows the vowels selected and their different environments. Because of the constraints placed on the data, I accept that certain gaps exist in my data sample. However, certain observations can be made based on the thirty forms in the above table. In the future I hope to expand my data sample as materials become available.

3.2 Methodology

The data were digitized in one channel using Sound Forge on a PC at a sampling rate of 22,050 Hz with 16-bit resolution. By examining the wave forms, I was able to determine the duration of the vowels; using the spectral analysis feature of Sound Forge, I generated broad band spectrograms to determine the formant structure of the vowels.[3]

Vowel duration was measured in milliseconds (ms) from the first glottal pulse to the final glottal pulse. My purpose here was to be consistent. In some cases, this method may not have been the best for determining the actual length of a vowel.[4] Figure 1 shows the wave form for *bəščəb*, 'mink.'

[3] For settings I used a Blackman-Harris smoothing window with an FFT size of 256 and an overlap of 1%. My frequency range was from 85 Hz to 3000 Hz.

[4] If the preceding consonant had been a voiceless consonant, there may have been some delay in the voicing of the vowel. It is conceivable that the period of silence should be considered part of the vowel. However, for the purposes of this preliminary study, even though it isn't the most accurate method of calculating duration, it allowed me to be more precise and consistent in my measurements.

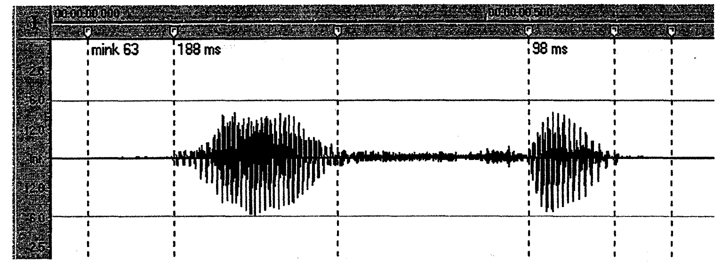

Figure 1 Wave form for bəščəb 'mink.'

The beginning and end points of each vowel are indicated by the dashed lines. Focussing on the first vowel, we see it is preceded by a voiced consonant. Since there are visible glottal pulses, I took this to be the onset of the vowel. The offset of the vowel was taken to be at the last glottal pulse. In this case, it coincides with the beginning of frication.

Vowel quality is reflected in the values of the first formant (F1) and the second formant (F2). Measurements were taken at the temporal midpoint of the vowel. Given that my data were not recorded for the purposes of doing spectral analysis, determining formant values was often difficult. In such cases, I also used spectrograms created by WinCECIL, with its formant tracking function, to help guide my analysis of formant values. A sample wave form with an accompanying spectrogram produced in Sound Forge is shown in Figure 2.

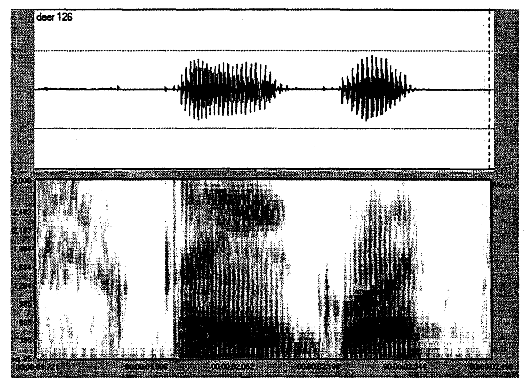

Figure 2 Wave form and spectrogram for sqigʷac 'deer'.

In the spectrogram, we see that the formant structure for the /i/ has a low F1, around 550 Hz, and F2 starts out low and rises sharply. At the temporal midpoint, a value of approximately 1900 Hz was recorded. The values for /a/ show that F1 is a bit higher, around 650 Hz; F2 is also rising, but it begins much lower than in /i/. At the midpoint a reading of 1250 Hz was taken.

4.0 Results and Discussion

Having outlined the nature of the data and methodology, I will now explore the results of my study. As stated above, I am only focussing on vowel duration and vowel quality. By vowel quality, I am referring only to the frequency of the first formant, whose value is in inverse proportion to vowel height. The frequency of the second formant corresponds to backness; a high value for F2 (2100 Hz) reflects a front vowel.

4.1 Vowel Duration

Testing for duration of vowels taken from narrative data can be a complicated situation. In narrative there are many levels of prosodic information that can affect the length of a given token. Lengthening and shortening of vowels is often done by storytellers to produce certain rhetorical effects which are significant to the genre. Often phrase final vowels are lengthened. In this case, vowel duration is probably best tested in relation to other vowels in the immediate environment, but this would be an extremely difficult task. The data I selected were pulled from their context according to the criteria outlined above. However, the durations of the vowels in my sample reveal a consistent pattern. In both the stressed and unstressed variants of each vowel, there is clear evidence that /a/ is always the longest vowel and /ə/ is always the shortest. The duration of /i/ closely matches /a/ and the duration /u/ falls between /i/ and /ə/.

4.1.1 Stressed Vowels

As we would expect stressed vowels are consistently longer than their unstressed counterparts. In my data, /á/ is the longest vowel. From the whole sample, the average duration of /á/ is 240 ms. However, there is one form with a consistently longer vowel, *sqas*. The average length of the four tokens is 309 ms, which is considerably longer than any token from other forms. There are two likely explanations for this lengthening: rhetorical effect or a long vowel. The first possibility seems plausible because each of the four instances of *sqas* occurs at the end of a phrase, a likely position for lengthened vowels. The case for this being phonetic evidence of a long vowel is also reasonable. It seems that there is evidence of the remnants of an /h/ in the form which could contribute to lengthening. Given its problematic status, I have removed this form from my summary in Figure 3.

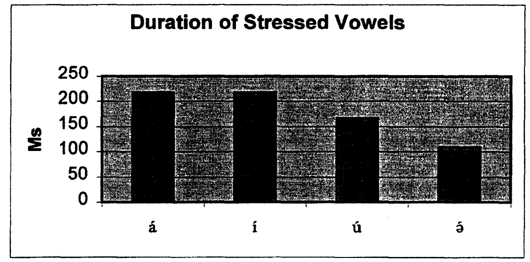

Figure 3 Duration of stressed vowels in milliseconds

As shown in the figure above, /á/ has an average duration of 218 ms, /í/ is very close to it with 217 ms, /ú/ is 163, and /ə́/ is the shortest with a duration of 109 ms. It appears that /á/ and /í/ are inherently longer that /ú/, and the three full vowels are all clearly longer than /ə́/.

These data are in line with phonetic facts from other Salish languages studies. Bessell (1997) finds that for St'at'imcets /a/ is the longest vowel, followed by /i/, then /u/, and finally /ə/. Considering the average vowel length for all four of her speakers, /i/ and /u/ are much closer in length than /i/ and /a/ . While this does not match my finding, it is interesting to note that for one of her speakers, GN, the length of /i/ is equal to /a/, a finding that is similarly reflected in Figure 3. Schwa is consistently shorter than the rest of the vowels for all speakers. Vowel duration is not addressed by either Flemming, Ladefoged and Thomason or Johnson and Ladefoged. These findings are reflective of the cross linguistic observation that low vowels are generally longer than high vowels. Lehiste refers to this phenomenon as "intrinsic duration," (1970:18), which is duration inherent in the vowel. One explanation for this is that the distance required by the tongue to move to a low vowel and back during phonation is greater than the distance necessary for a high vowel. (Maddieson 1996)

For Salishanists who take the position that stressed schwa is epenthetic, Figure 3 might serve as evidence for that analysis. Stressed schwa is shorter than the other vowels and presumably a shorter vowel can be correlated with being less of a vowel than the other three. But /ú/ is also shorter than the other two vowels, and it would still be considered a full vowel. Another possible interpretation is that length is a distinguishing factor. The vowel quality may be the distinguishing factor of /í/ and /á/ and even /ú/, but since the quality of schwa is so close to /á/, length in this case could be the distinguishing factor. However, for such a claim to be convincing, further study with very controlled data is necessary.

4.1.2 Unstressed Vowels

Unstressed vowels show a strikingly similar pattern. The duration of unstressed vowels are consistently shorter than their stressed counterparts, but in a way that marks their own distinctive length. /a/ is a bit longer than /i/ and /ə/ is again the shortest with /u/ in the middle, as seen in Figure 4.

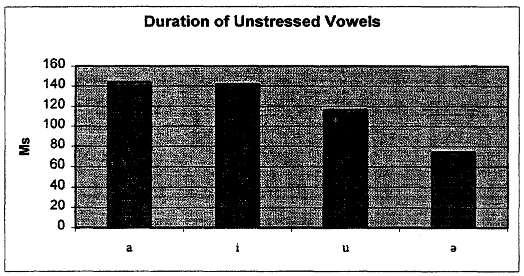

Figure 4 Duration of unstressed vowels in milliseconds

The data in Figure 4 reflect an average duration of 144 ms for /a/, 143 ms for /i/, 117 ms for /u/ and 75 ms for /ə/. This suggests that, at least for duration, unstressed environments do not cause full vowels to collapse to "schwa."

4.2 Vowel Quality

Vowel quality appears to be greatly affected by stress. Stressed vowels show a typical triangular pattern in their vowel space. Unstressed vowels are less robust in claiming definable regions, but there still remains a distinction in the vowel space. The lack of stress seems to contribute to the centralization of the vowels and their status is more a schwa-like variant of the respective vowel. Stressed and unstressed variants of /a/ appear to have the most consistently defined vowel space.

4.2.1 Stressed Vowels

Figure 5 shows the Formant Chart for stressed vowels. The data is taken from the values for vowels with a following velar consonant.[5] The vowels show a typical triangle pattern where the three corners of the triangle are marked by the targets of the full vowels. Schwa occupies the center of the space.

[5] The velar consonants are all rounded which will lower F1 and F2, but rounding should have a similar effect on each vowel token. I chose the velar series for two reasons. Firstly, it was the only series with stressed variants of the target vowel in forms with noun-like meanings. Secondly, the vowel space best represented the overall vowel space of all stressed vowels.

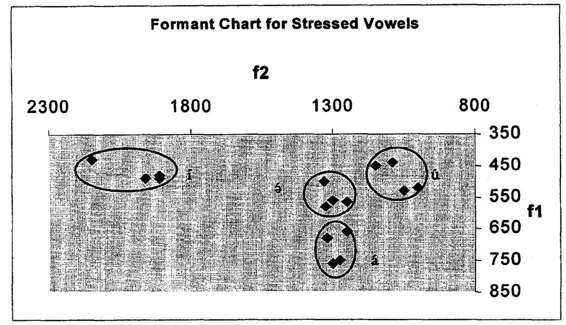

Figure 5 Formant chart for stressed vowels

This canonical vowel pattern is characterized by F2 being the distinguishing characteristic for disambiguating /í/ from /ú/, as expected. The F1 values for the pair are practically identical, while F2 is around 2000 Hz for /í/ and 1000 Hz for /ú/. On the other hand F2 for /á/ and /ə́/ are nearly identical, about 1300 Hz, whereas F1 proves to be the distinguishing factor with the F1/á/ being a bit higher than /ə́/. This suggests that if vowel duration is not perceptually significant in distinguishing vowels, vowel quality could be.

The data is Figure 5 are consistent to Bessell's findings for St'at'imcets. The plot for St'at'imcets vowel space is clearly defined with full vowels at the edges and schwa in the middle. The F1 and F2 values are a bit higher than in Figure 5, but this is quite possibly the result of the lowering caused by the context of a rounded consonant.

4.2.2 Unstressed Vowels

As is common in Salish languages, lack of stress contributes to the centralization of the vowels. It has been widely observed that unstressed vowels reduce to schwa. Although the vowel space shown in Figure 6 shows a much less clean picture than the stressed vowels above in Figure 5, it does not appear that all distinction is lost.

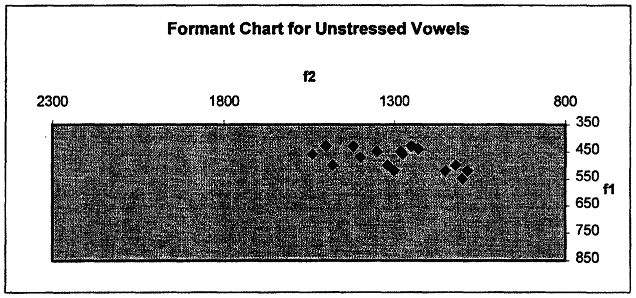

Figure 6 Formant chart for unstressed vowels

Figure 6 shows the unstressed vowels on the same scale as in Figure 5. The vowels are much closer together than the stressed counterparts, but it does not appear that all of the vowels have collapsed into one region. While F1 shows little variation F2 has considerable variability. Enlarging the scale of Figure 6 helps to clarify the situation.

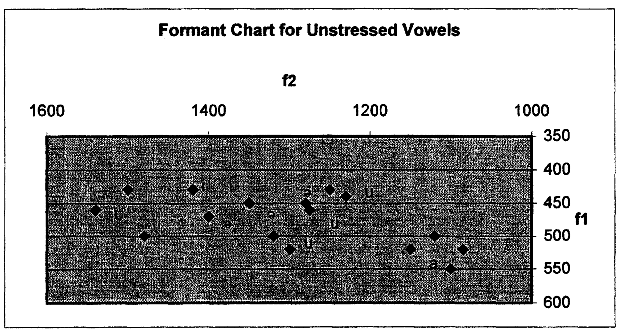

Figure 7 Unstressed vowels with scale adjusted

Figure 7 suggests that vowel space is still maintained for unstressed vowels. While specific regions in the vowel space are not nearly as clearly defined as the stressed vowels, there is consistent patterning. There certainly appears to be a clear region defined for /a/, and possibly for /i/, although the F1 values for /i/ are greatly reduced from those of /í/. However, separating /ə/ and /u/ is a bit more difficult. Both vowels occupy the center of the chart and the F1 and F2 values for the two are much less distinguishable.

Visually, there does seem to be four separate regions for unstressed vowels. It is unclear whether this constitutes a perceptible difference. While /i/ and /a/ are clearly at

opposite ends of the vowels space, /ə/ and /u/ are very close. One possibility for distinguishing between the two is rounding. Furthermore, since duration of unstressed vowels is more convincing, it is possible that vowel quality overlaid with duration provides an adequate perceptual cue.

5.0 Conclusion

In this paper I have presented phonetic data concerning the duration and quality of Lushootseed vowels in both stressed and unstressed environments. I have demonstrated that, for duration, the vowels appear to have a distinctive duration with respect to one another, whether stressed or unstressed. I have also shown that the vowel quality of stressed vowels defines a clear region in the vowel space, and have argued that there is also a discernable region defined by the quality of unstressed vowels. While further study is necessary, this preliminary analysis is at least suggestive that unstressed vowels do not simply reduce to schwa.

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