Sḵwx̱wú7mesh (Squamish Salish) Stress: A look at the acoustics of /a/ and /u/ *

Linda Tamburri Watt, Michael Alford, Jen Cameron-Turley, Carrie Gillon

University of British Columbia

Peter Jacobs

Squamish Nation Education

Preliminary results in this analysis show that in Sḵwx̱wú7mesh there is a resetting of the beginning of a stress domain when a strong suffix is attached to a root. This verifies a prediction made by Watt (2000) that strong suffixes are the second half of a prosodic compound. This is clear since the acoustic correlates of stress; namely, length, pitch and amplitude, are statistically the same on the vowel of a root whether or not a strong suffix is attached to it.

1 Introduction

1.1 Problem

In Sḵwx̱wú7mesh there are stress attracting suffixes. When these suffixes are attached to roots, adjacent stresses are permitted. This shows that a strong suffix has its own prosodic head and that it is the second half of a prosodic compound. Some questions which arise as a result are as follows: (i) what is perceived as stress in Sḵwx̱wú7mesh?, (ii) is the stress on a strong suffix different from the stress on a morphologically simplex stem? and (iii) is there stress on a monosyllabic root when a strong suffix is attached to it? The last question is the central to this paper and the first two questions will be answered in this pursuit.

1.2 Background stress facts[1]

In Sḵwx̱wú7mesh the first syllable of a morphologically simplex word is stressed if it contains a full vowel. The following bisyllabic words show that stress falls word initially.

(1)	a.	[sɬánay']	<slhánay'>	'lady'
	b.	[méχaɬ]	<míx̱alh>	'black bear'

As is typical cross-linguistically, schwa tends to resist being stressed in Sḵwx̱wú7mesh.[2] When the initial vowel in a bisyllabic word is a schwa and the final vowel is something other than schwa, stress falls on the final non-schwa vowel.

(2)	a.	[wənáχ^{w}]	<wenáx̱w>	'true/truth'
	b.	[sq^{w}əmáy']	<sḵwemáy'>	'dog'

* Sḵwx̱wú7mesh is a Coast Salish language spoken in the Burrard Inlet and Howe Sound area around Vancouver, British Columbia. There are fewer than twenty native speakers left. We would like to thank our Sḵwx̱wú7mesh consultant LB for sharing his langauge, and for his incredible patience and encouragement. Thank you also to the Squamish research group: Leora Bar-el, Henry Davis, Carrie Gillon, Peter Jacobs and Martina Wiltschko. Thanks also to Strang Burton, Laura Downing, Bryan Gick and Suzanne Urbanczyk. This research is funded by SSHRCC grant #410-951-519 to Henry Davis. Any errors are the authors'.

[1] See Bar-el and Watt (2000) for an analysis of the stress facts.

[2] Schwa is never stressed in other Salish languages like St'át'imcets (Lillooet), Lushootseed, Cowichan and Musqueam to name a few (Shaw &Roberts 1994, Urbanczyk 1996, Bianco 1996, Shaw et al. 1999).

In a bisyllabic word with only schwas, stress falls on the leftmost schwa.

(3)	a.	[χə́təʔ]	<xéte7>	'far'
	b.	[wə́χəs]	<wéxes>	'frog'

The following tri-syllabic roots indicate that Skwxwú7mesh builds trochaic feet interatively since secondary stress falls on the final syllable and primary stress falls on the initial syllable.

(4)	a.	[sxə́xopìt]	<shúhupìt>	'rabbit'
	b.	[mə́lalòs]	<mélalùs>	'raccoon'

The basic stress rule is stress the leftmost full (i.e., non-schwa) vowel or schwa if there are no full vowels and alternating vowels thereafter. In other words, Skwxwú7mesh builds trochaic feet from left to right. The basic pattern is not always observed in Skwxwú7mesh.

Weak suffixes follow the basic pattern and strong suffixes present some exceptions to the basic pattern since they are stress attracting. The descriptive rules with respect to these suffixes are as follows:

(5)

WEAK SUFFIXES:	never receive primary stress when preceded by a root which contains a full vowel
STRONG SUFFIXES:	receive primary stress without exception

When the weak suffixes are attached to a root, the basic stress pattern is observed and when the strong suffixes are attached to a root the basic pattern is not observed. The lexical suffixes *-ach* 'hand' and *-us* 'face' are not attracting stress. Notice in (6) and (7) that in words containing these lexical suffixes, the basic stress pattern is observed.

(6) *-ach* 'hand'

a. **<ts'lhulhach>**
√ts'ɬɔɬ=atʃ
cold=hand
[ts'ɬɔ́ɬatʃ]
'having cold hands'

b. **<t'u7ach>**
√t'ɔʔ=atʃ
sprain=hand
[t'ɔ́ʔatʃ]
'sprained wrist/hand'

c. **<chichipach>**
tʃetʃip=atʃ
ticklish =hand
[tʃétʃipàtʃ]
'ticklish hand'

(7) *-us* 'face'

a. **<kixus>**
√qɛχ=ɔs
=face
[qéχɔs]
'blind'

b. **<ts'esp'i7us>**
√ts'əsp'eʔ=ɔs
ugly=face
[ts'əsp'éʔɔs]
'ugly faced'

c. **<chichipus>**
tʃetʃip=ɔs
ticklish=face
[tʃétʃipɔ̀s]
'ticklish face'

The strong suffixes *-ullh* 'young specimen' and *-alh* 'times/instances' are stress attracting. Notice that when these suffixes are attached to roots, the basic stress pattern is not observed. We would expect a word like (8a) to have stress on the first syllable, but instead the final syllable is stressed. In (8b-d) we would expect primary stress to fall on the first syllable and secondary stress to fall on the final syllable, but instead primary stress falls on the final syllable.

(8) *-ullh* 'young specimen'

a. **<pushullh>**
√pɔʃ=ʔɔlɬ
cat=young.specimen
[pɔʃʔɔ́lɬ]
'kitten'

b. **<mixalhullh>**
√mɛχaɬ=ʔɔlɬ
bear=young.specimen
[mɛ̀χaɬʔɔ́lɬ]
'cub'

c. **<sixwalhullh>**
√sex^{w}aɬ=ʔɔlɬ
child=young.specimen
[sèxwaɬʔɔ́lɬ]
'young child'

d. **<musmusullh>**
√mɔ̀sməs=ʔɔlɬ
cow=young.specimen
[mɔ̀sməsʔɔ́lɬ]
'calf'

(9) *-alh* 'times/instances'

a. **<kw'inalh>**
√k^{w}'en=aɬ
how.many=times
[k^{w}'enáɬ]
'how many times'

<upenalh>
√ʔopen=aɬ
ten=times/instances
[ʔɔ̀pənáɬ]
'ten times'

<an7us=alh>
√ʔanʔos=aɬ
two=times/instances
[ʔànʔosáɬ]
'two times'

The words in (10) all have two adjacent stresses. From the basic stress pattern we would expect these words to surface with one stress on the second syllable; however, they surface with a stress on the second and third syllable.

(10) a. **<skwemay'ullh>**
√sq^{w}əmay'=ɔ́lɬ
dog=young.specimen
[sq^{w}əmày'ɔ́lɬ]
'puppy'

b. **<stekiw'ullh>**
√stəqew'=ɔlɬ
horse=young.specimen
[stəqèw'ɔ́lɬ]
'colt'

The basic stress pattern predicts words with four syllables to surface with primary stress on the first syllable and secondary stress on the third syllable. Instead, primary stress surfaces on the final syllable. Again, as is illustrated by the data in (11), strong suffixes always bear stress, even if it means stressing adjacent syllables.

(11) a. **<sxuxupitullh>**
√sxoxopet=ɔlɬ
rabbit=young.specimen
[sxòxopèt?ɔ́lɬ]
'baby rabbit'

b. **<xax7utsenalh>**[3]
√χaχ?otsən=aɬ
four=times/instances
[χaχ?òtsənáɬ]
'four times'

Following Czaykowska-Higgins (1998), Watt (2000) proposes that these suffixes are in two different morphological domains. The Proposed structure is outlined below.

(12) Morphological Structure[4]
[[[√ROOT]$_{MR}$ **WEAK$_1$**]$_{MS}$ [[**STRONG $_2$**] $_{MR}$]$_{MS}$]$_{MW}$

MR=morphological root
MS=morphological stem
MW=morphological word

This structure is motivated by historical evidence, synchronic evidence and evidence from Moses Columbia, an Interior Salish language. Watt's basic claim is that weak suffixes are part of the same domain for stress assignment as the MR and strong suffixes begin a new domain for stress assignment. This analysis predicts that (i) when strong lexical suffixes attach to mono-syllabic roots, the root should be stressed and (ii) the acoustic correlates of stress on a root should look similar whether or not a strong suffix is attached to it.

1.3 Predictions

The purpose of this paper is to test a prediction made by Watt (2000) in her claim that the stress domain resets with the addition of strong suffixes. The strongest prediction she makes in this paper is that monosyllabic words have stress when strong suffixes are attached to them. The prediction that roots should look the same whether or not they have a suffix attached to them will also be discussed briefly and, lastly, a discussion of the acoustic correlates of stress with respect to /a/ and /u/ will be discussed as a lead up to answering both of these questions.

2 Experiment

An experiment was conducted in order to test the predictions that monosyllabic roots are stressed even when stress attracting suffixes are attached to them and that the vowels contained in roots are the same acoustically whether or not there is a suffix attached to the particular root. In this pursuit vowel length, amplitude and pitch were examined in various positions.

2.2 Participant

For this preliminary study LB, a native speaker of Skwxwú7mesh was chosen. LB is male, he is in his late 60's, he is fluent in English and he is literate in Skwxwú7mesh and English.

2.2 Materials

In the field, a Marantz portable tape recorder was used to record the stimuli. The recordings were digitised using PC Utility and analysed using PCQuirer signal analysis software. Lastly, StatView statistics software was used for the statistical analyses.

[3] It is unclear at this point why stress is irregular in the root. Note that the root has also surfaced with a schwa in the first syllable.

[4] Although the distinction between morphological structure and phonological structure has been motivated in the literature (Czaykowska-Higgins 1998, Downing 1999), these domains are completely isomorphic in Skwxwú7mesh.

2.3 Methods

There are several steps involved in answering the question of whether or not a mono-syllabic root bears stress when it is attached to a strong lexical suffix. To answer this question it is necessary to analyse the acoustic correlates of both stressed and stressless vowels in mono-morphemic or highly grammatisized words of varying length, and the acoustic correlates of vowels contained in strong suffixes. Length, FØ and amplitude of phonemic /a/ and /u/ will be measured.[5] This study focus' on /u/ and /a/ for two reasons. First of all, vowels have an intrinsic fundamental frequency (FØ) (Ohala & Eukel 1987; Maddiesson 1997) so using only vowels of the same quality can be allows us to control for this. Secondly, the strong suffixes analysed in this study contain these vowels. Other variables which were considered in constructing the word list are (i) number of syllables in the word, (ii) which syllable contains the vowel being analysed and (iii) whether the vowel is contained within a strong suffix. More than one token of each word was collected. Since there are many bisyllabic and monosyllabic words, two tokens of each of these words were collected. On the contrary, morphologically simplex trisyllabic words do not exist, but there are a few trisyllabic words which are highly grammatisized. As a result of their rarity, five tokens of each of these words were collected. In constructing the list of stimuli, careful attention was also paid to selecting words without glottalized consonants as these are known to have a pitch affect on adjacent vowels. A quotative construction is an ideal carrier sentence for the stimuli since there is a distinct pause before and after the word of interest and thus the stress pattern is not affected. The carrier sentences is as follows:

(13) cut lha Lisa _____ kwi chelákłh
'Lisa said _____ yesterday'

The context for the sentence is that Lisa is a baby learning to talk and the speaker is telling someone about all the new words Lisa learned. LB, the Sḵwx̱wú7mesh speaker, read the sentence outlined in (13) containing the words in the list in five below. These words are organised by number of syllables, vowel quality and whether or not they contain a strong suffix. For the words containing strong suffixes, the root alone was also collected for comparative purposes.

(14) Sḵwx̱wú7mesh Stimuli[6]

ORTHOGRAPY	IPA	TRANSLATION	REPS
1. ilhen	élən	'eat'	2x
2. wex̱es	wéχes	'frog'	2x
3. skenu7	skənó?	'kind of dog'	2x
4. palḵw	palq'^{w}	'sprain'	2x
5. naxch	naxtʃ	'hand'	2x
6. ha7lh	ha?lh	'good'	2x
7. taḵw	taq^{w}	'to drink'	2x
8. natlh	natlh	'morning'	2x
9. push	poʃ	'cat'	7x
10. nuḵw	noq^{w}	'noon time'	2x
11. lhus	lhos	'slide down'	2x
12. lhukw	lhok^{w}	'be out of the way'	2x
13. kwu7s	kwo?s	'spring salmon'	2x
14. slhanay'	słáney'	'woman'	2x
15. tala7	tála?	'money'	2x
16. sata7	sáta?	'aunt'	2x
17. sḵaḵel	sqáqkəl	'one baby'	2x
18. maḵa7	máqa?	'snow'	2x
19. mix̱alh	méχaɬ	'black bear'	2x
20. maḵwam	mák^{w}am	'swamp'	2x

[5] The vowel /u/ has two allophones: [o] and [u]. The vowel [u] surfaces only in unstressed positions and [o] surfaces elsewhere (see Bar-el and Watt 1998 for further discussion).

[6] The list of words has been constructed from data which was previously collected by the primary author and Kuipers' (1967) Squamish grammar.

21. kwupits	kʷopits	'elder sibling'	2x
22. shupen	ʃópən	'to whistle'	2x
23. musmus	mósməs	'cow'	2x
24. susem	sósəm	'smell/stink'	2x
25. shukwa7	ʃókʷaʔ	'sugar'	2x
26. upen	ʔópən	'ten'	2x
27. lulum	lóləm	'sing'	2x
28. an7us	ʔánʔos	'two'	2x
29. s7atsus	sʔátsos	'face'	2x
30. kix̲us	qéχos	'blind'	2x
31. an7usk	ʔánʔosk	'two o'clock'	2x
32. itut	ʔitot	'sleeping'	2x
33. shuhupit	sxóxopèt	'rabbit'	5x
34. melalus	málalòs	'raccoon'	5x
35. t'akw'usach	t'ákw'osàtʃ	'seven'	5x
36. kw'in	kʷ'en	'how many'	2x
37. xax̲7utsen	χəχʔótsən	'four'	5x
38. an7us	ʔànʔos	'two'	2x
39. 7upen	ʔòpen	'ten'	2x
40. swik̲a7	swɛ́qaʔ	'man'	2x
41. mix̲alh	mɛ́xaɬ	'black bear'	2x
42. sk̲wemay'	sqwəmáy'	'dog'	2x
43. stek̲iw'	stəqéw'	'horse'	2x
44. hew'it	xáw'et	'rat'	2x
45. k'winalh	kʷ'en=áɬ	'how many times'	2x
46. xax̲7utsenalh	χəχʔotsən=áɬ	'four times'	2x
47. an7usalh	ʔanʔos=áɬ	'two times'	2x
48. upenalh	ʔopen=áɬ	'ten times'	2x
49. swik̲a7ullh	swɛqaʔ=ółɬ	'young man'	2x
50. mix̲alhullh	mɛxaɬ=ółɬ	'cub'	2x
51. sk̲wemay'ullh	skwəmay'=ółɬ	'puppy'	2x
52. stek̲iw'ullh	stəqew'=ółɬ	'barn'	2x
53. shuhupitullh	sxoxopet=ółɬ	'bunny'	2x
54. slhen'yullh	sɬeny=ółɬ	'young woman'	2x
55. pushullh	poʃ=ółɬ	'kitten'	5x
56. xew'itullh	xaw'wet=ółɬ	'baby rat'	2x
57. kelakela7ullh	kəlakəla=ółɬ	'baby crow'	2x
58. melk̲wullh	məqʷ=ółɬ	'baby lynx'	2x

The first six and the last four tokens of this list were discarded.

(15) Organisation of Stimuli

MONOSYLLABIC	BISYLLABIC	TRISYLLABIC	SUFFIXES
palqǁʷ	sɬáney'	sxóxopet	kʷǁen=áɬ
naxtʃ	tála?	málalòs	χəχʔotsən=áɬ
haʔlh	sáta?	t'ákw'osatʃ[7]	ʔanʔos=áɬ
taqʷ	sqáqkəl	χəχʔótsən	ʔopen=áɬ
natlh	máqaʔ		swɛqaʔ=ółɬ
poʃ	mɛχaɬ		mɛχaɬ=ółɬ
noqʷ	mákʷam		skwəmay'=ółɬ
lhos	kʷópits		stəqew'=ółɬ
lhokʷ	ʃópən		sxoxopet=ółɬ
kwoʔs	mósməs		sɬeny=ółɬ

[7] Only the final syllable of this word was considered.

k^{w}ɬen	sósəm ʃók^{w}a? ?ópən lóləm s?átsos qéχos ?án?osk ʔitot ?án?os ?ópen		xaw'wet=ółɬ poʃ=ółɬ
5x [a] 5x [o]	σ 1 = 9x [a] σ 1 = 8x [o] σ 2 = 6x [a] σ 2 = 5x [o]	σ 1 = 2x [a] σ 1 = 1x [o] σ 2 = 1x [a] σ 2 = 2x [o] σ 3 = 1x [a] σ 3 = 1x [o]	4x áɬ 7x óɬ

In the acoustic analysis, the length of the vowel in ms was calculated consistently conservatively, the FØ was calculated at the half way point of every vowel and the amplitude was calculated by finding the point of greatest intensity in each vowel. Measuring the FØ at the half way point in a vowel is consistent, however, this measurement failed to capture the fact that the suffix <ullh> triggers an extreme rise in pitch within the first 40-60 ms of the vowel. A standard ANOVA was the statistical method used in calculating the results of the experiment.

3 Results

3.1 Length

3.1.1 /a/

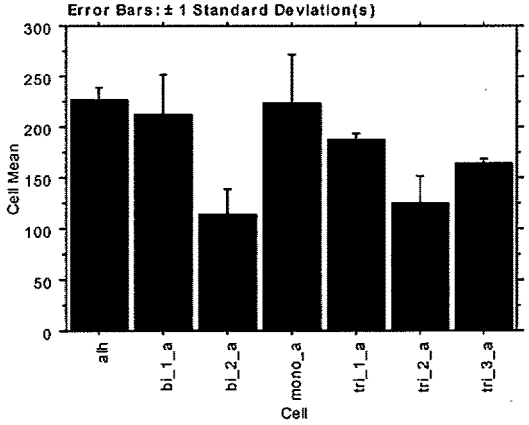
The mean length of the vowel /a/ in the first syllable of a bisyllabic word is 211.750ms, while the mean length of the same vowel in syllable two of a bisyllabic word is 114.571. These are statistically different since the P-Value is .0001. The mean length of a monosyllabic word containing /a/ is 223.667ms. The mean of a length of /a/ in all three syllables of a trisyllabic word are 187.600ms, 125.200ms and 164.200ms from syllable one to three. Lastly, the length of the vowel in the strong suffix <alh> is 227.250ms. Syllable one of both the bisyllabic and the trisyllabic word, the monosyllabic word and the vowel contained in the strong suffix are statistically the same. The P-Values range from .0813 and .3114. Syllable two of a bisyllabic and a trisyllabic word are statistically the same since the P-Value is .5268. Syllable two and three of a trisyllabic word have a P-Value of .0591 so they are statistically the same. Syllable one and three of tri-syllabic are statistically the same since the P-Value is .2529. The statistics involving length of the syllable /a/ in all positions are illustrated in the following charts.

(16)

Means Table for Some of ms
Effect: Some of Vowels

	Count	Mean	Std. Dev.	Std. Err.
alh	8	227.250	12.151	4.296
bi_1_a	20	211.750	39.459	8.823
bi_2_a	14	114.571	25.065	6.699
mono_a	9	223.667	48.485	16.162
tri_1_a	5	187.600	5.857	2.619
tri_2_a	5	125.200	26.281	11.753
tri_3_a	5	164.200	4.712	2.107

Interaction Bar Plot for Some of ms
Effect: Some of Vowels
Error Bars: ± 1 Standard Deviation(s)



Fisher's PLSD for Some of ms
Effect: Some of Vowels
Significance Level: 5 %

	Mean Diff.	Crit. Diff.	P-Value	
alh, bi_1_a	15.500	26.823	.2522	
alh, bi_2_a	112.679	28.417	<.0001	S
alh, mono_a	3.583	31.156	.8188	
alh, tri_1_a	39.650	36.553	.0340	S
alh, tri_2_a	102.050	36.553	<.0001	S
alh, tri_3_a	63.050	36.553	.0010	S
bi_1_a, bi_2_a	97.179	22.343	<.0001	S
bi_1_a, mono_a	-11.917	25.736	.3579	
bi_1_a, tri_1_a	24.150	32.059	.1371	
bi_1_a, tri_2_a	86.550	32.059	<.0001	S
bi_1_a, tri_3_a	47.550	32.059	.0043	S
bi_2_a, mono_a	-109.095	27.394	<.0001	S
bi_2_a, tri_1_a	-73.029	33.405	<.0001	S
bi_2_a, tri_2_a	-10.629	33.405	.5268	
bi_2_a, tri_3_a	-49.629	33.405	.0043	S
mono_a, tri_1_a	36.067	35.764	.0482	S
mono_a, tri_2_a	98.467	35.764	<.0001	S
mono_a, tri_3_a	59.467	35.764	.0015	S
tri_1_a, tri_2_a	62.400	40.552	.0031	S
tri_1_a, tri_3_a	23.400	40.552	.2529	
tri_2_a, tri_3_a	-39.000	40.552	.0591	

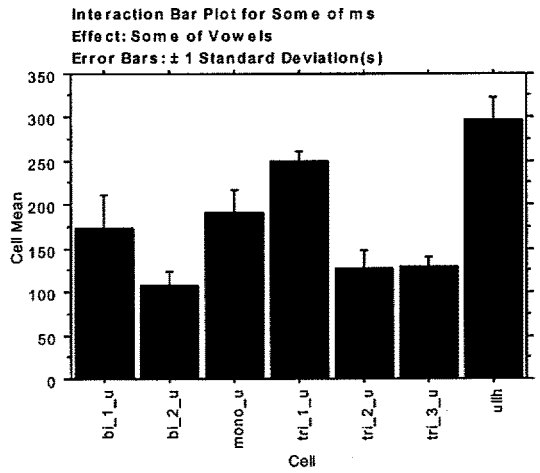
3.1.2 /u/

The mean length of the vowel /u/ in the first syllable of a bisyllabic word is 173.357ms and the mean length of the second syllable of a bisyllabic word is 108.200ms. These are statistically different since the P-Value is .0001. The mean length of /u/ in a monosyllabic word is 184.222. As seen with /a/, the vowel contained in the first syllable of a bisyllabic word is statistically the same as the vowel in the monosyllabic word. The mean length of /u/ in all three positions of a trisyllabic word are 250.600ms, 127.00ms and 129.600ms from syllable one to three. Syllable one is statistically different from syllables two and three, however, syllables two and three are statically the same. Unlike with /a/, the vowel contained in syllable one of a trisyllabic is statistically different from the vowel contained in syllable one of a bisyllabic word and a monosyllabic word. The mean length of the vowel in the strong suffix <ullh> is 297.083ms. This vowel is statistically different from the same vowel in all other positions. The statistics are illustrated in the charts bellow.

(17)

Means Table for Some of ms
Effect: Some of Vowels

	Count	Mean	Std. Dev.	Std. Err.
bi_1_u	14	173.357	37.637	10.059
bi_2_u	10	108.200	15.922	5.035
mono_u	10	190.900	26.876	8.499
tri_1_u	5	250.600	9.423	4.214
tri_2_u	5	127.000	20.543	9.187
tri_3_u	5	129.600	11.194	5.006
ullh	12	297.083	25.579	7.384



Fisher's PLSD for Some of ms
Effect: Some of Vowels
Significance Level: 5 %

	Mean Diff.	Crit. Diff.	P-Value	
bi_1_u, bi_2_u	65.157	21.711	<.0001	S
bi_1_u, mono_u	-17.543	21.711	.1111	
bi_1_u, tri_1_u	-77.243	27.319	<.0001	S
bi_1_u, tri_2_u	46.357	27.319	.0013	S
bi_1_u, tri_3_u	43.757	27.319	.0022	S
bi_1_u, ulh	-123.726	20.628	<.0001	S
bi_2_u, mono_u	-82.700	23.450	<.0001	S
bi_2_u, tri_1_u	-142.400	28.721	<.0001	S
bi_2_u, tri_2_u	-18.800	28.721	.1950	
bi_2_u, tri_3_u	-21.400	28.721	.1410	
bi_2_u, ulh	-188.883	22.452	<.0001	S
mono_u, tri_1_u	-59.700	28.721	.0001	S
mono_u, tri_2_u	63.900	28.721	<.0001	S
mono_u, tri_3_u	61.300	28.721	<.0001	S
mono_u, ulh	-106.183	22.452	<.0001	S
tri_1_u, tri_2_u	123.600	33.164	<.0001	S
tri_1_u, tri_3_u	121.000	33.164	<.0001	S
tri_1_u, ulh	-46.483	27.911	.0015	S
tri_2_u, tri_3_u	-2.600	33.164	.8757	
tri_2_u, ulh	-170.083	27.911	<.0001	S
tri_3_u, ulh	-167.483	27.911	<.0001	S

3.2 Pitch

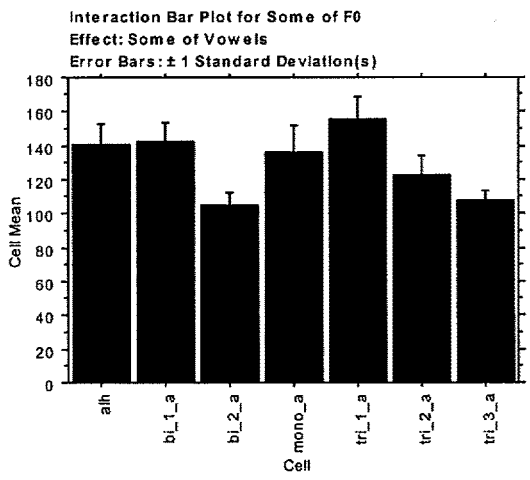
3.2.1 /a/

The mean pitch of /a/ when it is in the first syllable of a bisyllabic word is 142.300hz and 105.214hz when it is in the second syllable. With respect to pitch, these vowels are statistically different since the P-Value is .0001. The mean pitch of the vowel /a/ in a monosyllabic word is 136.222hz and the mean pitch of the vowel contained in the strong suffix <alh> is 140.625hz. The mean pitch of /a/ in the first syllable of a bisyllabic word, in a monosyllabic word and in <alh> is are statistically the same. The mean pitch of the vowel /a/ in all three positions of a trisyllabic word is 156.00hz, 122.400hz and 107.800hz from syllable one to three. The mean pitch of these vowels are statistically different. Although the first syllable of trisyllabic word has the highest mean pitch, it is statistically different from the mean pitch of the first vowel in a bisyllabic word, the vowel in a monosyllabic word and the vowel in the strong suffix <alh>. The statistics are shown below.

(18)

Means Table for Some of F0
Effect: Some of Vowels

	Count	Mean	Std. Dev.	Std. Err.
alh	8	140.625	12.478	4.412
bi_1_a	20	142.300	11.430	2.556
bi_2_a	14	105.214	6.818	1.822
mono_a	9	136.222	15.975	5.325
tri_1_a	5	156.000	12.767	5.710
tri_2_a	5	122.400	11.459	5.124
tri_3_a	5	107.800	5.263	2.354



Fisher's PLSD for Some of F0
Effect: Some of Vowels
Significance Level: 5 %

	Mean Diff.	Crit. Diff.	P-Value	
alh, bi_1_a	-1.675	9.442	.7239	
alh, bi_2_a	35.411	10.003	<.0001	S
alh, mono_a	4.403	10.967	.4250	
alh, tri_1_a	-15.375	12.867	.0200	S
alh, tri_2_a	18.225	12.867	.0063	S
alh, tri_3_a	32.825	12.867	<.0001	S
bi_1_a, bi_2_a	37.086	7.865	<.0001	S
bi_1_a, mono_a	6.078	9.059	.1846	
bi_1_a, tri_1_a	-13.700	11.285	.0182	S
bi_1_a, tri_2_a	19.900	11.285	.0008	S
bi_1_a, tri_3_a	34.500	11.285	<.0001	S
bi_2_a, mono_a	-31.008	9.643	<.0001	S
bi_2_a, tri_1_a	-50.786	11.758	<.0001	S
bi_2_a, tri_2_a	-17.186	11.758	.0049	S
bi_2_a, tri_3_a	-2.586	11.758	.6615	
mono_a, tri_1_a	-19.778	12.589	.0026	S
mono_a, tri_2_a	13.822	12.589	.0320	S
mono_a, tri_3_a	28.422	12.589	<.0001	S
tri_1_a, tri_2_a	33.600	14.274	<.0001	S
tri_1_a, tri_3_a	48.200	14.274	<.0001	S
tri_2_a, tri_3_a	14.600	14.274	.0452	S

3.2.2 /u/

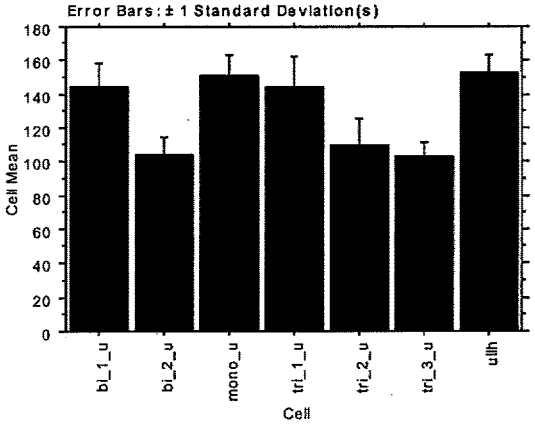
The mean pitch of the vowel /u/ in the first syllable of a bisyllabic word is 144.643hz and 104.500hz in the second syllable. These are statistically different. The mean pitch of the same vowel in a monosyllabic word is 149.333hz. The vowel /u/ in the strong suffix <ullh> has a mean pitch of 152.500hz. The mean pitch of the vowels in all three syllables of a trisyllabic word are 144.200hz, 103.200hz and 152.500hz from syllable one to three. With respect to pitch the first vowel of the bisyllabic word, the first vowel of the trisyllabic word, the vowel in the monosyllabic word and the vowel in the strong suffix <ullh> are statistically the same. The pitch of the vowel /u/ in the second syllable of a bisyllabic word and the second and third syllable of a trisyllabic word are also statistically the same. The statistics are shown the following charts.

(19)

Means Table for Some of F0
Effect: Some of Vowels

	Count	Mean	Std. Dev.	Std. Err.
bi_1_u	14	144.643	14.227	3.802
bi_2_u	10	104.500	9.698	3.067
mono_u	10	150.600	12.186	3.853
tri_1_u	5	144.200	18.199	8.139
tri_2_u	5	109.800	15.991	7.151
tri_3_u	5	103.200	8.438	3.774
ullh	12	152.500	11.091	3.202

Interaction Bar Plot for Some of F0
Effect: Some of Vowels
Error Bars: ± 1 Standard Deviation(s)



Fisher's PLSD for Some of F0
Effect: Some of Vowels
Significance Level: 5 %

	Mean Diff.	Crit. Diff.	P-Value	
bi_1_u, bi_2_u	40.143	10.596	<.0001	S
bi_1_u, mono_u	-5.957	10.596	.2647	
bi_1_u, tri_1_u	.443	13.334	.9472	
bi_1_u, tri_2_u	34.843	13.334	<.0001	S
bi_1_u, tri_3_u	41.443	13.334	<.0001	S
bi_1_u, ullh	-7.857	10.068	.1235	
bi_2_u, mono_u	-46.100	11.446	<.0001	S
bi_2_u, tri_1_u	-39.700	14.018	<.0001	S
bi_2_u, tri_2_u	-5.300	14.018	.4517	
bi_2_u, tri_3_u	1.300	14.018	.8532	
bi_2_u, ullh	-48.000	10.958	<.0001	S
mono_u, tri_1_u	6.400	14.018	.3641	
mono_u, tri_2_u	40.800	14.018	<.0001	S
mono_u, tri_3_u	47.400	14.018	<.0001	S
mono_u, ullh	-1.900	10.958	.7295	
tri_1_u, tri_2_u	34.400	16.186	<.0001	S
tri_1_u, tri_3_u	41.000	16.186	<.0001	S
tri_1_u, ullh	-8.300	13.623	.2272	
tri_2_u, tri_3_u	6.600	16.186	.4172	
tri_2_u, ullh	-42.700	13.623	<.0001	S
tri_3_u, ullh	-49.300	13.623	<.0001	S

3.3 Amplitude

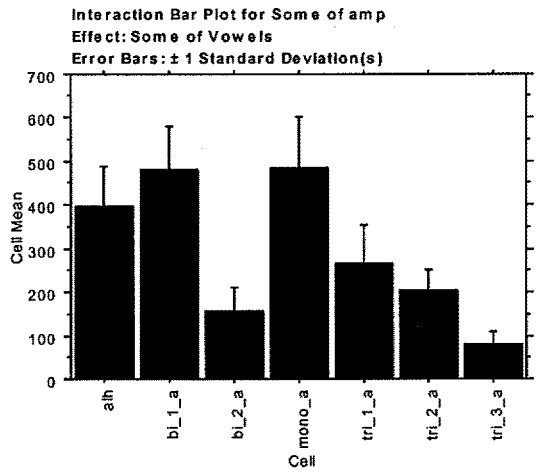
3.3.1 /a/

The mean amplitude of /a/ in syllable one and two of a bisyllabic word are 480.400db and 155.00db respectively. The mean amplitude of same vowel in a monosyllabic word is 484.333db. The mean amplitude of the vowel in the strong suffix <alh> is 396.375db. The mean amplitude of syllables one through three in trisyllabic words are 265.00db, 203.800db and 80.400db respectively. The amplitude of the first vowel in the bisyllabic word and the vowel in the monosyllabic word are statistically the same. Although the vowel in the strong suffix <alh> has a high mean amplitude compared second and third syllable of the longer words, it is still statistically different from the vowel in syllable one of the bisyllabic word and the vowel in the monosyllabic word. The comparisons are illustrated in the following charts.

(20)

Means Table for Some of amp
Effect: Some of Vowels

	Count	Mean	Std. Dev.	Std. Err.
alh	8	396.375	91.625	32.394
bi_1_a	20	480.400	97.609	21.826
bi_2_a	14	155.000	56.415	15.077
mono_a	9	484.333	116.648	38.883
tri_1_a	5	265.600	88.856	39.737
tri_2_a	5	203.800	49.464	22.121
tri_3_a	5	80.400	29.382	13.140



Fisher's PLSD for Some of amp
Effect: Some of Vowels
Significance Level: 5 %

	Mean Diff.	Crit. Diff.	P-Value	
alh, bi_1_a	-84.025	71.863	.0227	S
alh, bi_2_a	241.375	76.135	<.0001	S
alh, mono_a	-87.958	83.472	.0392	S
alh, tri_1_a	130.775	97.932	.0097	S
alh, tri_2_a	192.575	97.932	.0002	S
alh, tri_3_a	315.975	97.932	<.0001	S
bi_1_a, bi_2_a	325.400	59.861	<.0001	S
bi_1_a, mono_a	-3.933	68.952	.9095	
bi_1_a, tri_1_a	214.800	85.892	<.0001	S
bi_1_a, tri_2_a	276.600	85.892	<.0001	S
bi_1_a, tri_3_a	400.000	85.892	<.0001	S
bi_2_a, mono_a	-329.333	73.394	<.0001	S
bi_2_a, tri_1_a	-110.600	89.498	.0163	S
bi_2_a, tri_2_a	-48.800	89.498	.2797	
bi_2_a, tri_3_a	74.600	89.498	.1006	
mono_a, tri_1_a	218.733	95.817	<.0001	S
mono_a, tri_2_a	280.533	95.817	<.0001	S
mono_a, tri_3_a	403.933	95.817	<.0001	S
tri_1_a, tri_2_a	61.800	108.646	.2598	
tri_1_a, tri_3_a	185.200	108.646	.0012	S
tri_2_a, tri_3_a	123.400	108.646	.0267	S

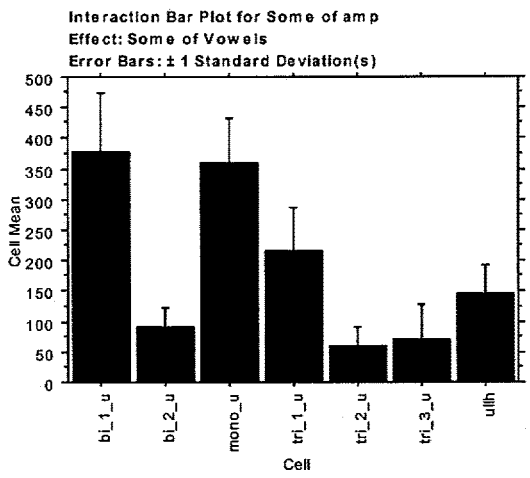
3.3.2 /u/

The mean amplitude of the vowel /u/ in the first syllable of a bisyllabic word is 376.643db and the mean amplitude of the same vowel in the second syllable of a bisyllabic word is 90.900db. The mean amplitude of /u/ in a monosyllabic word is 348.222db. The first vowel of the bisyllabic word and the vowel in the monosyllabic word are statistically the same with respect to amplitude. The mean amplitude of the vowels in syllable one through three in a trisyllabic word are 216.400db, 59.699db and 70.400db respectively. The vowel in syllable one of the trisyllabic word is statistically distinct from the vowel in the monosyllabic words and the vowel in the first syllable of the bisyllabic words. The vowels in syllables two and three of the polysyllabic words are statistically the same with respect to amplitude. The mean amplitude of the vowel contained in the strong suffix <ullh> is 144.667db. This is statistically different from the first vowel in the bisyllabic word and the vowel in the monosyllabic word. These statistics are illustrated in the following charts.

(21)

Means Table for Some of amp
Effect: Some of Vowels

	Count	Mean	Std. Dev.	Std. Err.
bi_1_u	14	376.643	98.091	26.216
bi_2_u	10	90.900	30.813	9.744
mono_u	10	359.100	73.340	23.192
tri_1_u	5	216.400	70.131	31.363
tri_2_u	5	59.600	32.176	14.390
tri_3_u	5	70.400	56.119	25.097
ullh	12	144.667	47.060	13.585



Fisher's PLSD for Some of amp
Effect: Some of Vowels
Significance Level: 5 %

	Mean Diff.	Crit. Diff.	P-Value	
bi_1_u, bi_2_u	285.743	55.663	<.0001	S
bi_1_u, mono_u	17.543	55.663	.5301	
bi_1_u, tri_1_u	160.243	70.041	<.0001	S
bi_1_u, tri_2_u	317.043	70.041	<.0001	S
bi_1_u, tri_3_u	306.243	70.041	<.0001	S
bi_1_u, ulih	231.976	52.888	<.0001	S
bi_2_u, mono_u	-268.200	60.123	<.0001	S
bi_2_u, tri_1_u	-125.500	73.635	.0012	S
bi_2_u, tri_2_u	31.300	73.635	.3979	
bi_2_u, tri_3_u	20.500	73.635	.5790	
bi_2_u, ulih	-53.767	57.563	.0665	
mono_u, tri_1_u	142.700	73.635	.0003	S
mono_u, tri_2_u	299.500	73.635	<.0001	S
mono_u, tri_3_u	288.700	73.635	<.0001	S
mono_u, ulih	214.433	57.563	<.0001	S
tri_1_u, tri_2_u	156.800	85.027	.0005	S
tri_1_u, tri_3_u	146.000	85.027	.0011	S
tri_1_u, ulih	71.733	71.561	.0495	S
tri_2_u, tri_3_u	-10.800	85.027	.8000	
tri_2_u, ulih	-85.067	71.561	.0207	S
tri_3_u, ulih	-74.267	71.561	.0422	S

3.4 Discussion

3.4.1 /a/

Since monosyllabic words containing /a/ consistently pattern with the first vowel of a bisyllabic word which is stressed, monosyllabic words must also be stressed. With respect to monosyllabic and bisyllabic words, the mean length pitch and amplitude for a stressed /a/ is approximately 210.00ms to 225.00ms, 136.00hz to 142.00hz and 480.00db to 485.00db. The strong suffix <alh> has a consistently high mean with respect to all three measurements, but it patterns statistically with the first vowel of a bisyllabic root and the vowel in the monosyllabic root with respect to length and pitch only. The first vowel in a trisyllabic word has a higher mean then vowels two and three with respect to length, pitch and amplitude; however, this vowel is statistically the same as the first syllable of a bisyllabic word and the vowel in monosyllabic words only in its length. Although there are some differences in syllables two and three of a trisyllabic words with respect to mean measurements, they are consistently statistically the same. Since the final two vowels of a trisyllabic

word and the final vowel of a bisyllabic word are consistently lower than the first syllable, it seems that these vowels are ether stressless or carry some kind of secondary stress. The mean with respect to length, pitch and amplitude of vowels with "non-primary" stress are as follows: the mean length is 114.00ms to 164.00ms, the mean pitch is anywhere from 107.00hz to 122.00hz and the mean amplitude is anywhere from 80.00db to 203.00db.

3.4.2 /u/

As is the case with /a/, the first /u/ in a bisyllabic word and the /u/ in a monosyllabic word are consistently the same statistically. The mean length, pitch and amplitude for a stressed /u/ in these positions is 173.00ms to 185.00ms, 144.00hz to 149.00hz and 348.00db to 376.00db. With respect to length and amplitude, the first vowel in a trisyllabic word and the vowel in the strong suffix <ullh> are considerably longer. It appears, therefore, that the vowels in these positions also carry primary stress even though they are statistically different from the same vowel in the first syllable of a bisyllabic word and a mono-syllabic word. However, both the first vowel in a trisyllabic word and the vowel in the strong suffix , <ullh> pattern with the first vowel of a bisyllabic word and the vowel in a monosyllabic word with respect to pitch. The mean measurements with respect to "non-primary" stress as represented by the second syllable of a bisyllabic word and the second and third syllables of trisyllabic words are 108.00ms to 129.00ms, 103.00hz to 109.00hz and 59.00db to 90.00db.

4 Roots and Strong Suffixes

In order to see whether or not the vowel contained within a monosyllabic word has stress when a strong suffix is attached to it, it is necessary to look at the vowel quality compare the acoustic correlates; namely, length, pitch and amplitude, of the both the vowel in the bare root and the root with a suffix attached to it. It is also necessary to compare this with the mean of all three measures in the various positions discussed. Notice in table (22)that the numbers look similar when comparing the bare form and the suffixed form and the suffixed form to the mean of the monosyllabic words containing /u/.

(22)

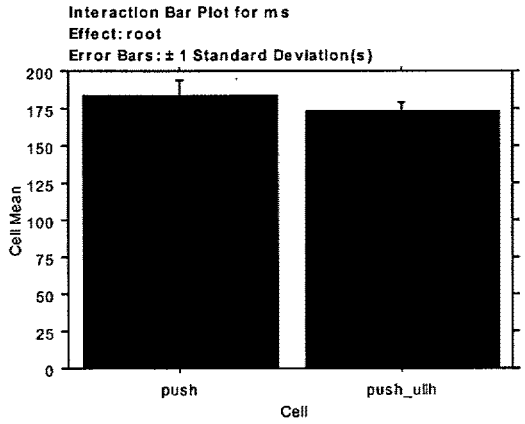
	VOWEL		
	ms	F0	amp
push (1)	179	163	478
push (2)	176	145	478
push (3)	202	148	482
push (4)	179	156	431
push (5)	180	157	406
push=ullh(1)	173	164	437
push=ullh(2)	180	143	388
push=ullh(3)	176	137	348
push=ullh(4)	174	136	361
push=ullh(5)	164	134	310
mono-u (mean)	184	149	348
bisyllabic σ-1 (mean)	173	144	376
bisyllabic σ-2 (mean)	108	104	90

Crucially, the vowel in the monosyllabic root does not resemble that of a vowel contained in syllable two of a bisyllabic word. In fact, the vowel contained in <push> is statistically the same whether or not it has a strong suffix attached to it. The following charts demonstrate that the length of the vowel /u/ in <push> is the same whether or not a suffix is attached.

(23)

Means Table for ms
Effect: root

	Count	Mean	Std. Dev.	Std. Err.
push	5	183.200	10.616	4.748
push_ulih	5	173.400	5.899	2.638



Fisher's PLSD for ms
Effect: root
Significance Level: 5 %

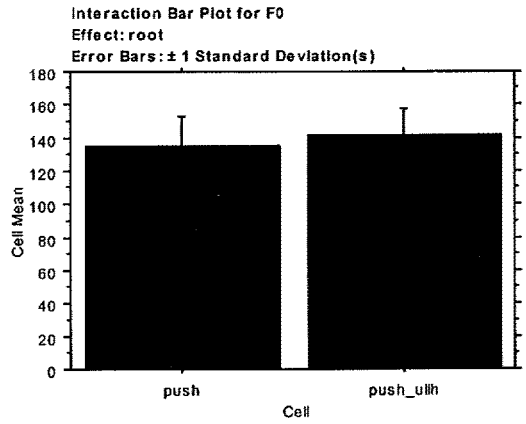
	Mean Diff.	Crit. Diff.	P-Value
push, push_ulih	9.800	12.525	.1088

As is demonstrated below, the pitch of the vowel in <push> is also statistically the same whether or not it has a strong suffix attached to it.

(24)

Means Table for F0
Effect: root

	Count	Mean	Std. Dev.	Std. Err.
push	5	134.600	18.623	8.328
push_ulih	5	142.000	15.050	6.731



Fisher's PLSD for F0
Effect: root
Significance Level: 5 %

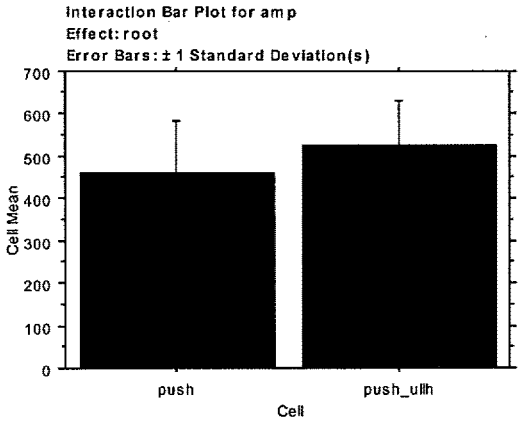
	Mean Diff.	Crit. Diff.	P-Value
push, push_ulh	-7.400	24.693	.5091

As is illustrated below, the amplitude is also statistically the same.

(25)

Means Table for amp
Effect: root

	Count	Mean	Std. Dev.	Std. Err.
push	5	460.000	122.992	55.004
push_ulh	5	525.400	104.825	46.879



Fisher's PLSD for amp
Effect: root
Significance Level: 5 %

	Mean Diff.	Crit. Diff.	P-Value
push, push_ulh	-65.400	166.657	.3919

These preliminary results support Watt's (2000) claim that there is a resetting of the stress domain with the addition of a strong suffixes. These preliminary results also indicate that mono-syllabic words have stress when they are attached to strong suffixes.

5 Conclusion

This paper has explored the acoustic correlates of stress with respect to /a/ and /u/ in Sḵwx̱wú7mesh. The results show that length, pitch and amplitude are relevant when distinguishing primary and secondary stress; however, in tri-syllabic words the distinction between secondary stress and tertiary stress is less clear. It is also unclear whether the last syllable of a bisyllabic word patterns with the second or third syllable of a tri-syllabic word. This paper has also shown that the length, pitch and amplitude of a monosyllabic word when a suffix is attached to it is the same as the mean of all three correlates of a monosyllabic word. This supports the claim made in Watt (2000) that there is a resetting of the stress domain with the addition of strong suffixes.

References

Bar-el, Leora and Linda Tamburri Watt. 1998. What Determines Stress in Sḵwx̱wú7mesh (Squamish)? *33rd International Conference on Salish and Neighboring Languages*, 407-427.

Bar-el, Leora and Linda Tamburri Watt. 2000. Word internal constituency in Sḵwx̱wú7mesh (Squamish)? Paper presented at *WSCLA 5*, University of Toronto.
Bianco, Violet. 1995. Stress in Lushootseed. *30th International Conference on Salish and Neighbouring Languages.*
Czaykowska-Higgins, Ewa. 1998. The Morphological and Phonological Constituent Structure of Words in Moses-Columbia Salish (Nxaʔamxcín). In Czaykowska-Higgins & Kinkade, *Salish Languages and Linguistics: Theoretical and descriptive perspectives*. 153-195.
Downing, Laura. 1999. Prosodic Stem ≠ Prosodic Word in Bantu. In Hall & Kleinhenz *Current Issues in Linguistic Theory: Studies on the Phonological Word*. p. 74-98.
Kuipers, Aert H. 1967. *The Squamish Language: Grammar, Texts, Dictionary*. The Hague: Mouton and Co.
Maddieson, Ian. 1997. Phonetic Universals. In HoPS, eds. W. Hardcastle and J. Laver. Malden: Blackwell Publishers.
Ohala, John J. and Brian W. Eukel. 1987. Explaining the Intrinsic Pitch of Vowels. _____. Dordrecht: Foris Publications.
Roberts, Taylor & Patricia Shaw. 1994. Optimality in the St'át'imcets (Lillooet Salish) stress system. Paper presented at *CLA*, Calgary.
Shaw, Patricia, Susan Blake, Jill Campbell and Cody Shepherd. 1999. Stress in Musqueam Salish *UBC Working Papers in Linguistics* Volume 2.
Urbanczyk, Suzanne C. 1996. Patterns of reduplication in Lushootseed. Ph.D. dissertation, University of Massachusetts, Amherst.
Watt, Linda Tamburri. 2000. What's in the Input? A look at prespecification in Optimality Theory. Paper presented at *SCIL 12*, University of Arizona.

Appendix A: Key to Sḵwx̱wú7mesh Orthography

Orthography	IPA	Orthography	IPA
p	p	kw	k^w
p'	pˀ	kw'	$kˀ^w$
m	m	xw	x^w
m'	mˀ	ḵ	q
t	t	ḵ'	qˀ
t'	tˀ	ḵw	q^w
ts	ts	ḵw'	$qˀ^w$
ts'	tsˀ	x̱	χ
s	s	x̱w	$χ^w$
n	n	h	h,x
ch	tʃ	w	w
ch'	tʃˀ	y	j
sh	ʃ	y'	jˀ
lh	ɬ	e	ə
tl'	tlˀ	i	i,e,ɛ
l	l	u	u,o,ɔ
k	k	a	a
k'	kˀ	7	ʔ