L1 English Perception of /x/ and /xʷ/ in Kwak'wala and hul'q'umi'num'

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With 34 unique Indigenous languages and 90 different dialects, British Columbia is a linguistically diverse province in Canada. With so much diversity in such concentration, there is limited work on comparing unrelated languages found in near geographical locations. This study investigates the differences between two languages found on Vancouver Island: Kwak'wala and hul'q'umi'num'. Listeners' perception of Kwak'wala and hul'q'umi'num' plain and labialized /x/ and /xʷ/ was investigated to determine whether L1 English speakers are able to differentiate between the two sounds, as well as determine whether there is a difference between perception across the two languages. Results indicate that /x/ was more accurately perceived in both languages, most notably in hul'q'umi'num'. In Kwak'wala, plain and labialized segments were more accurately perceived in word-initial position.In hul'q'umi'num', plain and labialized segments were more accurately perceived in word-final position. Analyses between the two languages found that participants perceived Kwak'wala more accurately than hul'q'umi'num'. Results suggest there may be differences in production between the two languages that affect the perception of English speakers, such as duration and environmental context of the segment. A practice effect was found across listening quiz trials, where participants more accurately perceive plain and labialized segments on the second trial.
Key words: labialization; word positioning; perception; velar fricatives; Indigenous languages

1 Introduction

In the province of British Columbia alone, there are 203 First Nations communities and 34 unique Indigenous languages with each community having their own culture, traditions, and history (Dunlop et al., 2018). However, the number of fluent speakers continues to decline each year with the loss of many of the older first language speakers, which further exemplifies the importance of revitalizing these languages for future language learners.

In this study, we examined the effects of L1 English in perception of labialization in Kwak'wala and hul'q'umi'num', two Indigenous languages spoken in British Columbia. We examined whether L1 English speakers will be able to differentiate between the plain velar fricative /x/ and labialized velar fricative /xʷ/. We conducted an identification task using JATOS (Lange et al, 2015), a tool used

to create online studies, and recruited 12 participants for data collection. We hope that our study will be a contribution to the language revitalization movement in British Columbia and help encourage others to explore the many different languages spoken on this land.

2 Background

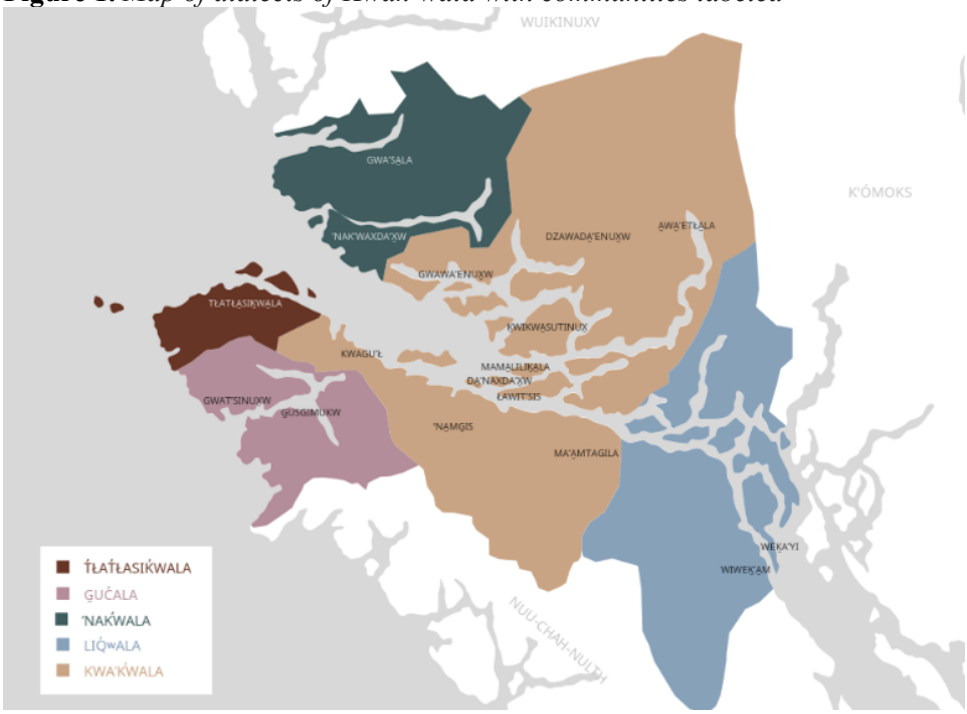
In section 2.1, the language history such as the number of speakers and where the languages are spoken will be examined, along with the consonant inventories of Kwak'wala and hul'q'umi'num'. In section 2.2, past research on cross-linguistic differences in perception and production of similar sounding segments as well as the effects of word positioning will be presented. In section 2.3, past research on L1 effects on the perception of contrasts which do not occur in the L1 will be examined. Finally, in section 2.4 there will be a summary of past findings, our research questions, and a statement of our hypothesis.

2.1 Language History

The Wakashan language family consists of seven languages, split into the northern and southern branches. The southern branch includes diitiidʔaatx̱, Nuučaan̓uł and Makah and the northern branch includes Hailhzaqvla, Kwak'wala, Oowekyala and X̄enaksialak̓ala/X̄a'islak̓ala (Dunlop et al., 2018,)[1]. Kwak'wala has several dialects which are quite different from each other and is spoken on north Vancouver Island and the smaller islands and mainland directly to the east. Kwak'wala had 139 fluent speakers in 2018, which is a significant decline from 2016, where they had 425 mother tongue speakers. However, they had 763 active language learners in 2018 (Dunlop et al., 2018). Figure 1 below illustrates where Kwak'wala is spoken in British Columbia:

[1] For both languages, the 2018 FPCC report uses different definitions when compared to the 2016 census (for more information on definitions of speakers, see p. 20 of 2018 report) (Dunlop et al., 2018).

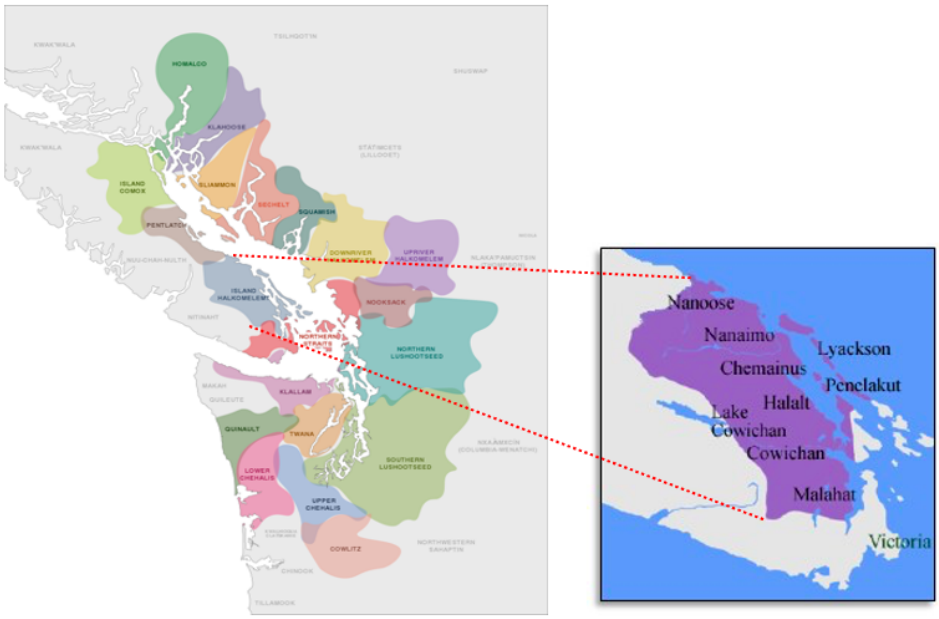
Figure 1. *Map of dialects of Kwak'wala with communities labeled*



Note. Noahedits. (2019). Reproduced following CC-BY-SA 4.0, (https://commons.wikimedia.org/w/index.php?curid=79638031).

The Salishan Language Family is made up of 23 languages in the Pacific Northwest in B.C, and the states of Washington, Idaho and Montana (Dunlop et al., 2018). There are three subgroups: Nuxalk (Bella Coola), Coast Salish and Interior Salish. hul'q'umi'num' (east coast of Vancouver Island), Halq'eméylem (Fraser Valley) and Hən̓q̓əmin̓əm (Lower Mainland) are three distinct dialects of the same Coast Salish language, Halkomelem, which is important to note as these names sound similar and are often mistaken as being one dialect. hul'q'umi'num' had 93 fluent speakers in 2018 compared to 585 Mother Tongue speakers in 2016 and there were 1,238 active language learners in 2018 (Dunlop et al., 2018). Figure 2 below illustrates where hul'q'umi'num' is spoken in British Columbia:

Figure 2. *(a) Map of Coast Salish linguistic distribution in early to mid 1800s; (b) the communities that speak the hul'q'umi'num' dialect*



(a) (b)

Note. Image (a) Noahedits, (2019), reproduced following CC-BY-SA 4.0 (https://en.wikipedia.org/wiki/Coast_Salish_languages#/media/File:Coast_Salish_language_map.svg). Image (b) created by Michelle Parent (used with permission from the artist).

We chose to examine the labialized velar fricative /x^{w}/ and the plain velar fricative /x/ for this study as both languages have these two contrasting segments in their inventories (shown in Figure 3 and 4 below). Both languages also have other contrasting segments as well, such as the plain uvulars /q/ and /χ/ compared to the labialized uvulars /q^{w}/ and /χ^{w}/ and the plain velar /k/ and the labialized velar /k^{w}/, which future studies could further examine.

The following figure illustrates the segment inventory for Kwak'wala:

Table 1. *Kwak'wala consonant inventory, in IPA*

p	t	t͡ɬ	tʃ	k	kʷ	q	qʷ	ʔ
p'	t'	t͡ɬ'	tʃ'	k'	k'ʷ	q'	q'ʷ	
b	d		dz	g	gʷ	ɢ	ɢʷ	
		ɬ	s	x	xʷ	χ	χʷ	h
m	n	l		y	w			
m'	n'	l'		y'	w'			

The following figure illustrates the segment inventory for hul'q'umi'num':

Table 2. *hul'q'umi'num' consonant inventory, in IPA*

p		t			k	kʷ	q	qʷ	ʔ
p'		t'				k'ʷ	q'	q'ʷ	
	tθ	tʃ		ts					
	t'θ	tʃ'	t͡ɬ	t's					
	θ	s	ɬ	ʃ	x	xʷ	χ	χʷ	h
m		n	l	y		w			
m'		n'	l'	y'		w'			

2.2 Cross-Linguistic Differences in Perception and Production of Similar Sounding Segments

There has been previous work investigating cross-linguistic differences in the perception and the production of segments which sound similar to one another, as well as previous production studies on /x/ and /xʷ/. Previous studies indicate that duration may influence perception of segments cross-linguistically. Kim (2010) examined lip rounding as a secondary articulation on consonants in English, Korean and Nuu-chah-nulth and found that there is a difference in phonetic aspects cross-linguistically in /kʷ/. All three languages showed different durations of the labialized segment but their length relation with the labialized velar was consistent. Gordon et al. (2002) examined labialized segments in various word positioning (word-initially, word-medially, and word-finally) and measured elements of the

surface realizations of segments such as duration, center of gravity and overall spectral shape for voiceless fricatives. Results indicate that there is phonetic variability in duration cross-linguistically for the plain velar /x/, as well as cross-linguistically between plain and labialized segments. In Hupa, the labialized velar fricatives did not differ noticeably in their spectral properties but in Montana Salish, the labialized velars and uvulars had lower F1 and F2 values in their vowel transitions compared to the plain uvulars (Gordon et al., 2002). Based on the studies mentioned above, we expect Kwak'wala and hul'q'umi'num' to have different phonetic properties in labialization, such as length, which could influence perception of segments.

2.3 Effect of Environment on Segment Identification

Another aspect of the current study focuses on the perception of unfamiliar contrasts which do not occur in the L1. Mellesmoen, and Babel (2020) conducted a perception experiment examining /θ/ and /s/ in Halkomelem and ʔayʔaǰuθəm. They found that English listeners categorised ʔayʔaǰuθəm fricatives more accurately in CV context than VC and the contrast was most substantial when in onset position. Other past perception studies found that young children can discriminate between speech contrasts not found in their L1 up until they are around a year old, then their ability declines (Smith, 1997; Werker & Tees, 1984). This could indicate that our participants could be unable to hear the contrast between plain and labialized velar fricatives in our experiment, as it is not apparent in their L1. Future studies could investigate whether younger children are better at differentiating between the plain velar fricative /x/ and labialized velar fricative /xʷ/ in hul'q'umi'num' and Kwak'wala compared to adults.

2.4 Summary, Research Questions and Hypotheses

Based on evidence from previous studies mentioned above, our current study seeks to increase our understanding of the effects of an individual's L1 on the perception of unfamiliar segment contrasts. We will also examine the effects of word position on the accuracy of participants' perception of contrasts. Furthermore, we will investigate the differences in perception of the same sounds (i.e., /x/ and /xʷ/) which exist in both Kwak'wala and hul'q'umi'num'.

Our study will examine whether L1 English speakers can perceive a difference between the plain (/x/) and labialized (/xʷ/) velar fricative. Based on the work by Gordon et al., (2002), there is phonetic variability in duration cross-linguistically for the plain velar /x/, as well as cross-linguistically between plain and labialized segments. we hypothesize that L1 English speakers will be able to perceive a difference between the plain (/x/) and labialized (/xʷ/) velar fricative.

Regarding the effects of environment on segment identification, we will examine whether the location of the plain (/x/) and labialized (/xʷ/) velar fricative within the word will affect perception. Based on the work by Mellesmoen and Babel (2020) where they found that English listeners categorised ʔayʔaǰuθəm

fricatives more accurately in CV context than VC and the contrast was most substantial when in onset position, we hypothesize that the location of the plain (/x/) and labialized (/xʷ/) velar fricative within the word will influence perception.

Lastly, we will examine whether there is a significant difference in perception of the plain (/x/) and labialized (/xʷ/) velar fricatives between Kwak'wala and hul'q'umi'num'. Based on previous work that found differences in acoustic measures (such as duration and formant frequency) between languages for labialized segments cross-linguistically (Kim, 2010; Gordon et al., 2002) we expect that participants will demonstrate differences in perceptual accuracy between the two segments across Kwak'wala and hul'q'umi'num'. We hypothesize that there will there be a significant difference in perception of the plain (/x/) and labialized (/xʷ/) velar fricatives between Kwak'wala and hul'q'umi'num'.

3 Methods

In section 3.1, the stimuli that were used in this perception study will be discussed such as the origins of the audio files and in what word positioning /x/ and /xʷ/ appeared in both languages (full word lists provided in Tables 1–4). In section 3.2, the participant data will be examined and in section 3.3, the experimental procedure will be discussed such as how the identification task works and what participants were asked to do. Finally in section 3.4, we will discuss how the data will be analyzed such as looking at overall participant accuracy rates in both quizzes and investigating the audio files on Praat (Boersma & Weenink, 2018) to see if there are any differences in duration of labialization in both languages.

3.1 Stimuli/Data

The following stimuli were collected from FirstVoices (2022), an interactive public site designed to promote Indigenous languages by having recordings of audio, as well as songs, stories, and a history of the language. We also had access to audio files extracted from a hul'q'umi'num' corpus that we have access to through Dr. Sonya Bird, a professor at the University of Victoria, as part of her current grant exploring hul'q'umi'num' pronunciation (Bird et al., in press). Data used in this study consisted of words in Kwak'wala and hul'q'umi'num' which included /x/ and /xʷ/ in word-initial, word-medial, and word-final position. The segments under investigation in this study occurred in a vocalic environment, i.e., never directly beside a consonant, to control for any variation due to environmental context. A vocalic environment is one in which the target sound has a vowel either preceding, following or on both sides of a consonant. Due to limited data, we could not exactly replicate the vocalic environments of plain and labialized segments cross-linguistically, so segments differed in vocalic environments containing high, mid, or low vowels. Tables 3–6 below lists the tokens which were used in this study categorized by word positioning:

Table 3. *Kwak'wala plain /x/*

Word-initial	Word-medial	Word-final
xaḵ̓adzu "backbone of a fish"	da̲**x**a "open your eyes (to have eyes open)"	wa**x** "although"
xum's "head"	alea**x**a̲n "let me seek"	wax'me**x** "although I"
xatsa̲'es "low tide"	łok'walala**x**i "let him speak strong"	ts̓up̓a'**x** "mittens/gloves"

Table 4. *Kwak'wala labialized /x^{w}/*

Word-initial	Word-medial	Word-final
x^{w}ak̓wala "the sound of a frog croaking"	'ma̲**x**^{w}'id "iron clothes, start to admire something, beginning of month"	di**x**^{w} "yellow cedar"
x^{w}iba̲ta̲we' "whistle as you walk along"	dła**x**^{w}a "respond to invitation"	ga̲'yu**x**^{w} "red alder"
x^{w}ak̓wa̲na "canoe"	ti̓**x**^{w}a "bruised/a bruise"	ga̲ti̓nu**x**^{w} "good artist, or one who makes things well"

Table 5. *hul'q'umi'num' plain /x/*

Word-initial	Word-medial	Word-final
xu'athun "four"	wu**x**us "tree frog"	qu**x** "lots"
xatsa' "lake"	slhe**x**un' "medicine"	hququ**x** "become many"
xetl' "windy (stormy breeze)"	mumu**x**elh "caterpillar"	tth'u**x** "worn out, burn, come to an end (month)"

Table 6. *hul'q'umi'num' labialized /x^{w}/*

Word-initial	Word-medial	Word-final
x^{w}iqw'ut "loop it"	yu**x**^{w}ule' "bald eagle"	qwi**x**^{w} "miss"
x^{w}um' "fast"	sa**x**^{w}ul "grass"	suy'i**x**^{w} "loosened, undone"
x^{w}aaqw' "sawbill, merganser"	sa**x**^{w}ulalus "green, grass coloured"	sqwulqwal**x**^{w} "hail"

3.2 Participants

We recruited 12 L1 English speakers of all genders and ages between 18–40 years old, as to control for any potential loss of hearing which could be a conflict in our results. We recruited individuals via social media and targeted participants who have limited knowledge of Indigenous languages. We collected information about the languages that participants have previous knowledge of to control for potential exposure to other languages which contain plain and labialized consonant contrasts examined in this study.

3.3 Task/Experimental Procedure

We created two online quizzes hosted on the online server JATOS and jsPsych for our data collection (Lange et al., 2015; de Leeuw, 2015). The format was an identification task, where participants listened to a sound and were given two choices to choose from, as to what they think they heard. Each quiz contained 18 questions: 2 target sounds (/x/ and /xʷ/), 3 positions (word-initial, word-medial, or word-final) and 3 words in each word positioning. Half of the participants recruited for this study were exposed to the Kwak'wala quiz first, and the other half were exposed to the hul'q'umi'num' quiz first, however the participants did not know which language they were currently being tested on.

We decided to split the two languages into their own quiz to see whether there was a general trend towards one language over the other in overall accuracy rates and to reduce participant fatigue by giving the participants a break in between the two quizzes. Before the study began, the participants were asked if they consent to the study and whether their data could be used in the study. Then we exposed the participants to a 'tips' screen which described the articulation of the segments, as well as played two audio files containing /x/ and /xʷ/ by itself (retrieved from the interactive IPA, 1999), labelled in order to familiarize the participants to the contrasting segments.

We asked the participants to complete the quiz on their laptop/computer, use headphones and to be in a quiet environment for this study. Once the participants were familiar with the task, each audio file played the word once and the participant decided if the segment they heard was /x/ or /xʷ/. When the participant got the segment wrong, they had the chance to re-listen to the sound and click the correct segment on the second try. All questions were randomized within the study and each participant completed one hul'q'umi'num' and one Kwak'wala quiz but did not know which language they were listening to. The completion of both quizzes took roughly 30–40 minutes, but we instructed participants to take at least a 5-minute break in between quizzes.

3.4 Data Analysis

To test for perceptual ability, we will compare L1 English speakers' accuracy rates in correctly choosing /x/ or /xʷ/ between hul'q'umi'num' and Kwak'wala. We will

compare the results to determine if there are any cross-linguistic differences between the two languages. We will also examine accuracy of results depending on if a segment is in word-initial, word-medial, or word-final position. To explain possible trends in our data, we will analyze tokens in Praat (Boersma & Weenink, 2018) to see if there are any differences in duration that could influence accuracy rates. We will also examine practice effects to see if participants perform better on the second quiz regardless of which language quiz they do first.

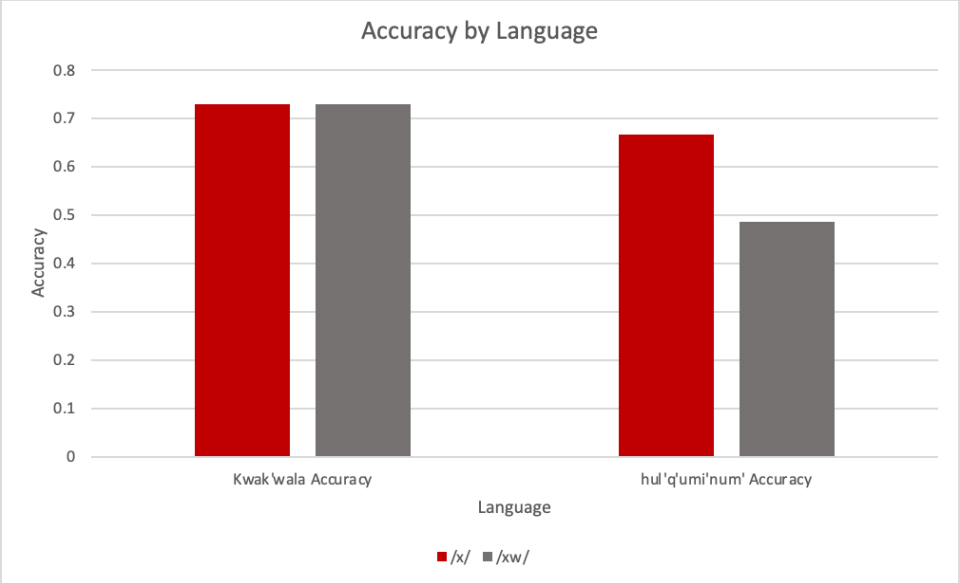
4 Results

This section examines our results from the two identification tasks which were performed by our participants. In section 4.1, we examine the cross-linguistic differences in participants' perception between /x/ and /x^{w}/ in both languages. In section 4.2, we examine the participants' perception of /x/ and /x^{w}/ based on word positioning. In section 4.3, we discuss possible practice effects which were examined between the two quizzes.

4.1 Overall Perceptual Accuracy of /x/ and /x^{w}/ in hul'q'umi'num' and Kwak'wala

Our results indicate that participants perceived both /x/ and /x^{w}/ more accurately in Kwak'wala compared to hul'q'umi'num'. As well, most participants accurately perceived /x/ more often than /x^{w}/ in hul'q'umi'num', but in Kwak'wala there seems to be no significant difference between the perception of /x/ and /x^{w}/ (i.e., similar accuracy rates for both segments). Overall, participants perceived both /x/ and /x^{w}/ as the correct segment in Kwak'wala 73% of the time compared to hul'q'umi'num' where participants perceived /x/ as the correct segment 67% of the time and /x^{w}/ at a rate of 49% of the time. Figure 3 below shows the accuracy rates of both /x/ and /x^{w}/ in both languages:

Figure 3. *Overall perception accuracy of /x/ and /x^{w}/ in hul'q'umi'num' and Kwak'wala*



4.2 Overall Perceptual Accuracy of /x/ and /x^{w}/ Based on Word Positioning

Figure 4 below examines participants' accuracy rates for /x/ and /x^{w}/ by word positioning in Kwak'wala. Our results for Kwak'wala indicate that participants' accuracy rates for both /x/ and /x^{w}/ are relatively close to each other when they both appear in the same word positioning. As well, most participants accurately perceived both /x/ and /x^{w}/ in Kwak'wala when the segment appeared in word-initial position. Overall accuracy rates for perceiving /x/ was 90% and /x^{w}/ was 87% in word-initial positioning in Kwak'wala. For word-medial position in Kwak'wala, participants perceived both /x/ and /x^{w}/ accurately at a rate of 67% and for word-final position, participants accurately perceived /x^{w}/ at a rate of 67% and /x/ at a slightly lower rate of 62%.

Figure 4. *Participant accuracy rates of /x/ and /x^{w}/ based on word positioning for Kwak'wala*

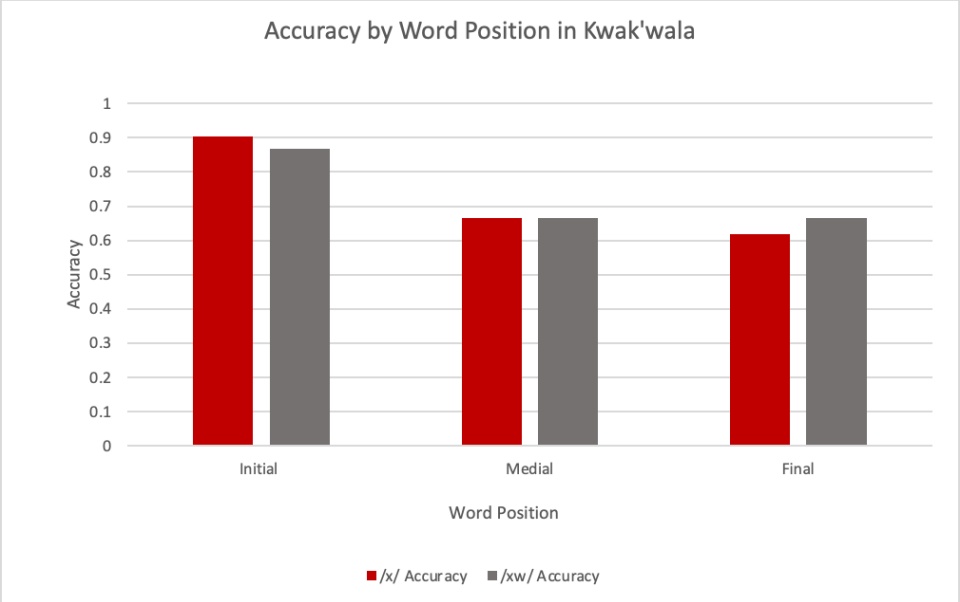
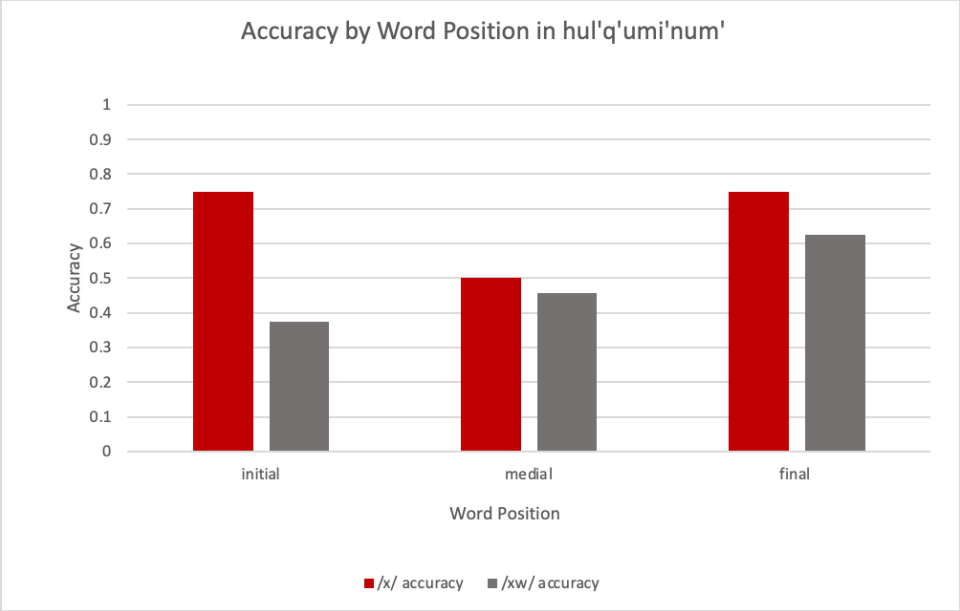


Figure 5 below examines participants' accuracy rates for /x/ and /x^{w}/ by word positioning in hul'q'umi'num'. Participants most accurately perceived /x/ when it was in word-initial and word-final position. Furthermore, there were the most incorrect trials when /x/ appeared in word-medial position. The perception of /x^{w}/ got steadily more accurate from the lowest scores being in word-initial position, to the most accurate scores being in word-final position. For hul'q'umi'num', participants' accuracy rates for word-initial positioning for /x/ was 75% of the time and /x^{w}/ 38% of the time. For word-medial position, participants accurately perceived /x/ half of the time and /x^{w}/ 49% of the time. Word-finally, participants accurately perceived /x/ 75% of the time and /x^{w}/ 63% of the time.

Figure 5. *Participant accuracy rates of /x/ and /x^{w}/ based on word positioning for hul'q'umi'num'*



5 Discussion

The following section will discuss the main findings of this study and briefly relate them to acoustic analyses of segments. Firstly, we will discuss the differences in perception between Kwak'wala and hul'q'umi'num'. Next, we will discuss the differences in perception between the two languages in relation to word position. Finally, we will discuss the main differences between the plain and labialized segment across the two languages.

5.1 Cross-Linguistic Differences

The results from this study indicate that there is a difference in English perception of the plain and labialized velar fricatives between Kwak'wala and hul'q'umi'num'. It was found that between the two languages, Kwak'wala had a higher perceptual accuracy than that of hul'q'umi'num'. Furthermore, the results from the Kwak'wala quiz demonstrated that participants were equal in their perceptual accuracy of the two segments. The results of the hul'q'umi'num' quiz, however, demonstrate both a lower overall accuracy as well as more variation in accuracy across segments. Participants seemed to less accurately perceive /x^{w}/ in hul'q'umi'num', perceiving the correct segment less than 50% of the time. Overall, results demonstrate that participants more accurately differentiate between /x/ and /x^{w}/ in the Kwak'wala quiz when compared to the results of the hul'q'umi'num' quiz.

Segment duration of the tokens used in this study was examined as a possible indication as to why there was a difference in perception across Kwak'wala and hul'q'umi'num'. Results (as seen in Figure 3) do not indicate that the Kwak'wala had more accurate perception based on segment duration, as all segments between the two languages occur around the same length as demonstrated in Table 7 (between 227–297ms). Other studies, however, have investigated the coarticulation of /x/ and /x^{w}/ into the following vowel as a possible explanation for more accurate perception of labialization, suggesting that vowel height may affect perception (Maeda, 1999). Other measurements of the segments, such as those done by Maeda (1999) may need to be investigated in order to determine what possible aspects of production may influence the accuracy of perception of listeners.

Table 7. *Average Duration of Segments, According to Language*

Segment	Kwak'wala	hul'q'umi'num'
/x/	262ms	227ms
/x^{w}/	287ms	297ms

Note: Refer to Appendices A through D to see examples of how measurements were taken for analyses.

5.2 Differences of Segments Based on Word Position

Results from the quizzes indicate that location of the segment within the word may hold influence over perceptual accuracy. Segmental duration between the two languages demonstrates similar patterns across word positioning (as seen in tables 8 and 9). Both Kwak'wala and hul'q'umi'num' demonstrate the longest duration in word-final position, approximately 150–200ms longer than segments in word-initial and word-final position.

Table 8. *Average Duration of /x/ and /x^{w}/ in hul'q'umi'num Tokens, According to Position*

Segment	Word-initial	Word-medial	Word-final
/x/	169ms	149ms	364ms
/x^{w}/	281ms	208ms	402ms

Note: Refer to Appendices A through D to see examples of how measurements were taken for analyses.

Table 9. *Average Duration of /x/ and /xʷ/ in Kwak'wala Tokens, According to Position*

Segment	Word-initial	Word-medial	Word-final
/x/	238ms	192ms	357ms
/xʷ/	286ms	226ms	350ms

Note: Refer to Appendixes A through F to see examples of how measurements were taken for analyses.

This may indicate why participants were more accurate in their perception of /x/ and /xʷ/ in word-final position for the hul'q'umi'num' quiz but does not explain why participants were more accurate at perceiving /x/ and /xʷ/ in word-initial position for the Kwak'wala quiz.

Mellesmoen and Babel (2020) may give insight for a possible reason for perception being more accurate in word-initial position for Kwak'wala. They argue that perception of English listeners is more accurate in CV position than in VC (2020). However, while this would explain why word-initial position in Kwak'wala is most accurate (as all our word-initial tokens are a CV sequence), it does not explain why the word-final position in hul'q'umi'num' is the most accurate. As the word-final position tokens in the hul'q'umi'num' (and Kwak'wala) quiz are in VC sequence, these results from our study demonstrate the opposite of what Mellesmoen and Babel (2020) argue. However, it is entirely possible that both the duration and the environment context of /x/ and /xʷ/ may influence participant perception. Further investigation of duration and environmental context is required in which a wider range of tokens must be examined, with a more controlled environmental context around /x/ and /xʷ/. As we were limited in available tokens, we cannot make any concrete conclusion of the effect of preceding and postceding vowels on segment perception. However, the results of this study give a preliminary analysis of vowel effect on the fricatives used in our stimuli and may indicate future studies for further investigation. Furthermore, there may be variability across speakers in which production of the segment differs, so it may be beneficial to test perception based off tokens produced by one speaker only.

5.3 Differences Between /x/ and /xʷ/

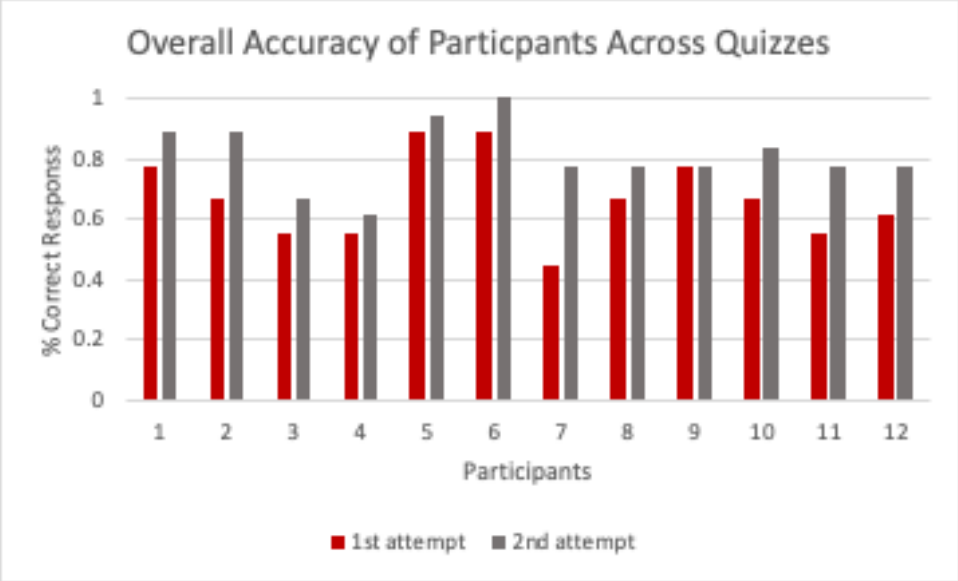
Results from this study suggest that participants were less accurate at perceiving labialized segments when compared to the plain segments, most notably in hul'q'umi'num'. This suggests that our L1 influences perception, leading us to perceive unfamiliar segments as the most similar segment in our L1 inventory. Upon examination of duration across the tokens used in this study, we can see that on average, the labialized segment has a longer duration (approximately 25ms longer for Kwak'wala tokens, and approximately 70ms longer for hul'q'umi'num' tokens). These results do not follow the findings from other studies that suggest the duration of the segment articulation may possibly aid participant perception of

segments (Stonham & Kim, 2008; Gordon et al., 2002; Ham, 2008). Further investigation of the effects of duration is required.

5.4 Practice Effect

It should be noted that results across the two trials also indicate a practice effect, as most participants performed on average 14% better on the second quiz regardless of which language quiz they encountered first. The following figure demonstrates participant accuracy between the first and second attempt:

Figure 8. *Participant Accuracy Across Quiz Attempts*



These results imply that an increase of exposure to segmental contrasts will increase an individual's ability to perceive contrasts that they have no prior experience with. If there is an increase of accuracy in perception with increased exposure to the segment contrast (approximately 25% more accurate on the second trial than the first in some cases), it is possible that individuals may gain a higher proficiency in perception of the language with routine practice and testing of the segments. These results provide an exciting preliminary result that could hold implications for Indigenous language learners that hope to build on perceptual awareness of contrasts found in their ancestral language that are not in their first language.

6 Conclusion

This paper examined English L1 perception of plain and labialized /x/ and /x^{w}/ in Kwak'wala and hul'q'umi'num' to investigate English speakers' perception of the

two sounds across the two languages as well as in different word-positions. Results from two listening quizzes were collected, finding that participants perceived Kwak'wala more accurately than hul'q'umi'num'. Furthermore, results indicate that /x/ was more accurately perceived by participants in both languages, most notably in hul'q'umi'num'. The results from the Kwak'wala quiz demonstrate that both /x/ and /xʷ/ were equally perceived by participants and were most accurately perceived in word-initial position. The results from the hul'q'umi'num' quiz demonstrate that both /x/ and /xʷ/ were more accurately perceived in word-final position. Evidence of a practice effect suggests that participants become more accurate in their perception of plain and labialized segments as exposure increases, providing implications to possible techniques for learning contrasts within languages that are not an individual's L1. Duration was examined as a possible explanation as to the differences in results across the two languages but did not provide any solid evidence for the differences in participant accuracy across languages and between word positioning.

Further research could conduct a more in-depth analysis of the production of the plain and labialized segments within Kwak'wala and hul'q'umi'num', in which the coarticulation effects between the labialized segments and their preceding and postceding vowels are investigated. Furthermore, it would be interesting to extend the analysis of plain and labialized contrasts to other segments found in both language inventories as well, such as other velar segments (/k/ and /kʷ/), and uvular segments (/χ/ and /χʷ/, /q/ and /qʷ/). It would be interesting to include other Indigenous languages found on Vancouver Island, as well as coastal Salish languages in perception and production analyses of the plain and labialized contrasts.

7 Acknowledgments

We would like to acknowledge the privilege that we have had to be able to analyze and learn from Indigenous languages. A special thank you to the FirstVoices website in making Kwak'wala and hul'q'umi'num' data accessible to the public and to Dr. Sonya Bird who gave us access to hul'q'umi'num' audio files through her work with members from the hul'q'umi'num' Language and Culture Society and the hul'q'umi'num' Language Academy. Further thank you to Tess Nolan for helping create the testing materials used to collect data in this study.

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Appendix A

Segment	Word-initial position	Word-medial position	Word-final position
/x/	**x**u'athun - 0.152	wu**x**us - 0.189	qu**x** - 0.390
/x/	**x**atsa' - 0.091	slhe**x**un' - 0.116	hququ**x** - 0.371
/x/	**x**etl' - 0.264	mumu**x**elh - 0.143	tth'u**x** - 0.330
/x/ Average	0.169	0.149	0.364
/x^{w}/	**x^{w}**iqw'ut -0.116	yu**x^{w}**ule' -0.252	qwi**x^{w}** -0.370
/x^{w}/	**x^{w}**um' - 0.115	sa**x^{w}**ul -0.155	suy'i**x^{w}** -0.386
/x^{w}/	**x^{w}**aaqw' -0.613	sa**x^{w}**ulalus - 0.218	sqwulqwal**x^{w}** - 0.450
/x^{w}/ Average	0.281	0.208	0.402

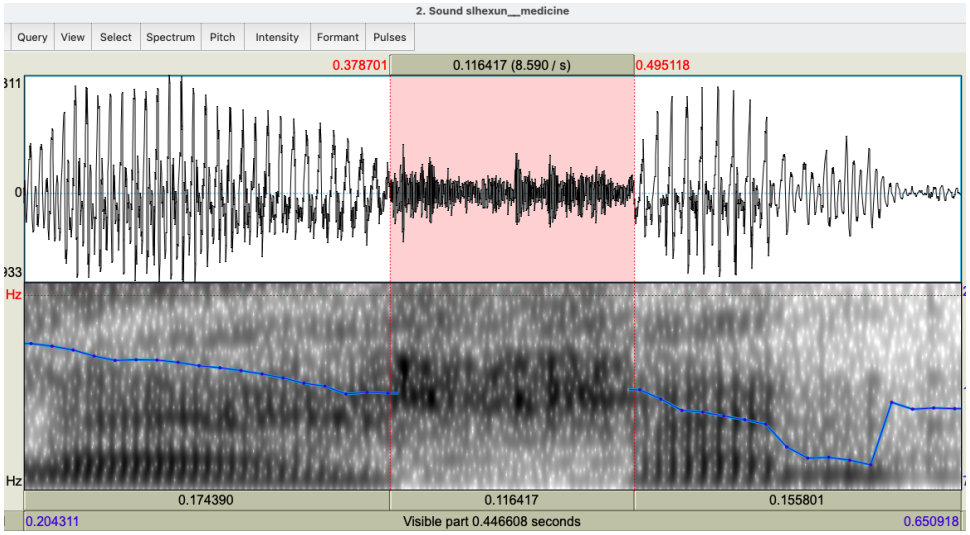
Appendix A. hul'q'umi'num' Token Durations in Seconds

Appendix B

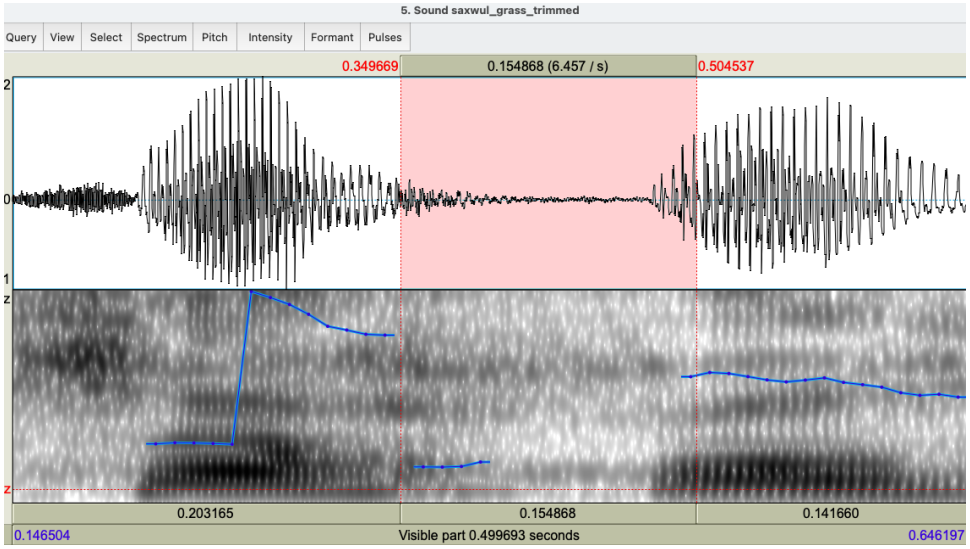
Segment	Word-initial position	Word-medial position	Word-final position
/x/	**x**aka̓dzu -0.253	da̲**x**a -0.194	wa**x** -0.426
/x/	**x**um's -0.217	alea**x**a̲n -0.196	wax’me**x** -0.347
/x/	**x**ata̓sa̲'es -0.243	łok’walala**x**i - 0.186	t̓supa̓'**x** -0.299
/x/ Average	0.238	0.192	0.357
/x^{w}/	**x**^{w}aka̓wala -0.268	‘ma̲**x**^{w}’id - 0.207	di**x**^{w} -0.352
/x^{w}/	**x**^{w}iba̲ta̲we' - 0.298	dła**x**^{w}a -0.268	ga̲’yu**x**^{w} -0.271
/x^{w}/	**x**^{w}aka̓wa̲na - 0.293	t̓i**x**^{w}a -0.203	ga̲t̓inu**x**^{w} -0.426
/x^{w}/ Average	0.286	0.226	0.350

Appendix B. Kwak’wala Token Durations in Seconds

Appendix C

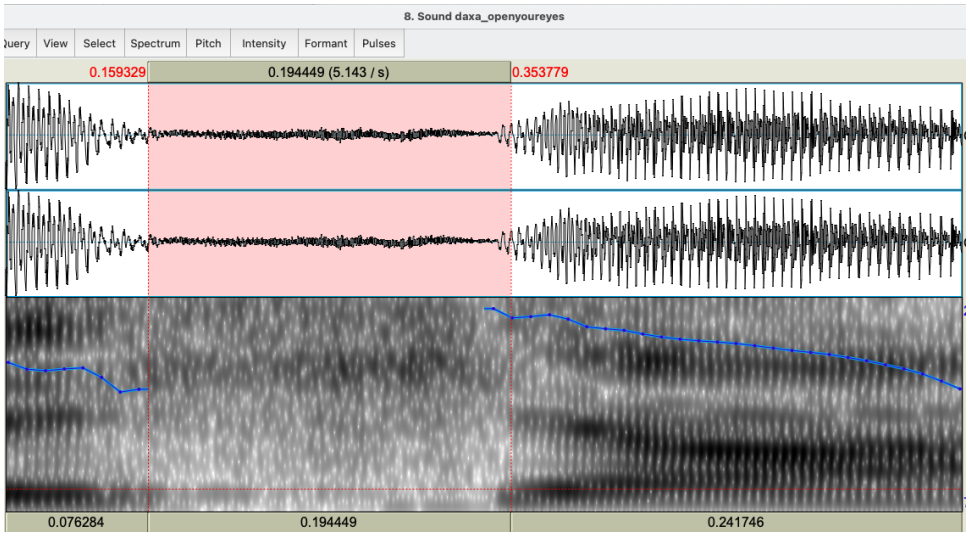


Appendix C1. Praat Measurement of hul’q’umi’num’ /x/ in slhexun’ *medicine*, in Milliseconds.

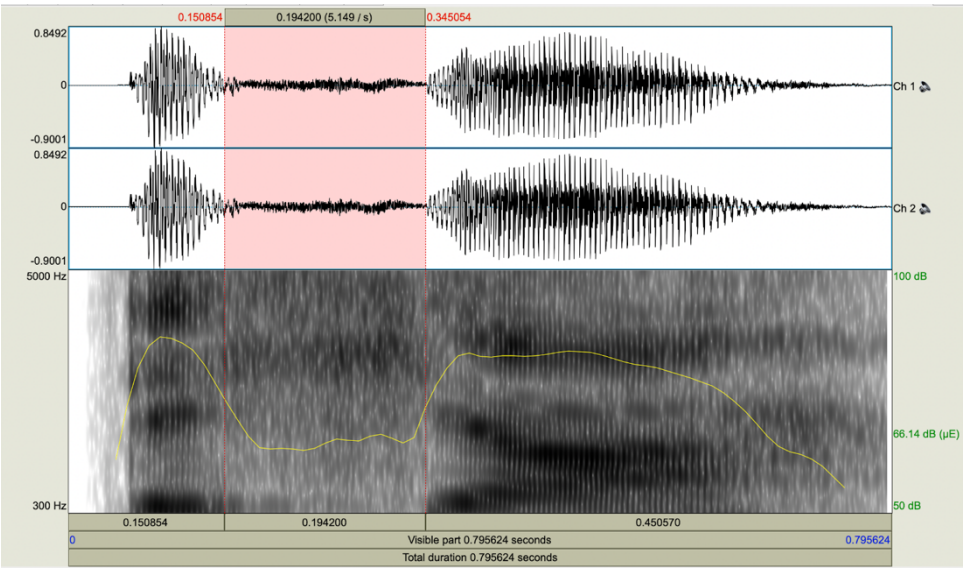


Appendix C2. Praat Measurement of hul'q'umi'num' /x^{w}/ in sax^{w}ul *grass*, in Milliseconds.

Appendix D



Appendix D1. Praat Measurement of Kwak'wala /x/ in daxa *open your eyes*, in Milliseconds



Appendix D2. Praat Measurement of Kwak'wala /xʷ/ in dłaxʷa *respond to invitation*, in Milliseconds