THE RELATIONSHIP BETWEEN PRONUNCIATION AND ORTHOGRAPHY: USING ACOUSTIC ANALYSIS AS A PRACTICAL ILLUSTRATION OF ʔayʔaǰuθəm (COMOX-SLIAMMON) VOWEL QUALITY

Gloria Mellesmoen & Marianne Huijsmans

University of British Columbia
gloria.mellesmoen@ubc.ca; mebhuijs@ubc.ca

ABSTRACT

Phonetic analysis is a powerful tool in supporting evidence-based community decisions regarding orthographic representation, such as whether graphemes correspond to underlying or surface forms. This is the first systematic acoustic description of vowels in ʔayʔaǰuθəm (Comox-Sliammon), an endangered language spoken in British Columbia. The measurements reported in this paper illustrate the categorical and gradient properties of vowels across different environments. This description has proved useful in informing ongoing discussions regarding orthographic representation used for a community-based dictionary project. The mapping between underlying and surface forms is central to this discussion. The current orthography encodes surface vowel quality, but learners must also be aware of underlying representations when identifying morphemes. In this paper, we confirm that variation in ʔayʔaǰuθəm vowel quality is conditioned by adjacent consonants. This phonetic investigation has informed conversations within the community that focus on how pronunciation of vowels varies and the implications this has for the orthography.

Keywords: language revitalization, Comox-Sliammon, Salish, orthography, vowels

1. INTRODUCTION

In the context of language revitalization, it is not uncommon for communities to be writing their language for the first time. Developing and implementing a writing system involves decisions that address how to represent the language in an accessible and accurate way. While linguists may be asked to advise during the process, it is not our role to make decisions, but instead to assist the community in making informed choices.

Bassetti ([1]) describes a continuum of "phonological transparency" which categorizes various orthographic systems by the degree to which the mapping from grapheme to phoneme is clear. It is further emphasized that orthography is able to facilitate or hinder L2 acquisition of pronunciation or phonemic representations. A transcription system based on surface forms privileges transparency in pronunciation, while one based on underlying forms may aid in the identification of morphemes and the phonological processes with affect their realization. The mapping between underlying and surface forms, and its predictability, is central to the discussion of orthographic representation.

2. BACKGROUND

ʔayʔaǰuθəm (Comox-Sliammon) is a Central Salish language traditionally spoken in the K'ómoks, Tla'amin, Homalco, and Klahoose communities in British Columbia, with roughly 47 L1 speakers [4].

Previous impressionistic description suggests that the surface vowel quality of the four phonemic vowels (/a i u ə/) is heavily influenced by adjacent uvular and palatal consonants [2,5,6]. Examples from fieldwork are shown in (1) and (2). /i/ is retracted to [ɛ] before a uvular consonant in (1), and /a/ is raised to [ɛ] following a palatal in (2). As both /i/ and /a/ are realized as [ɛ], the identity of the underlying vowel is unclear. In the orthography, which privileges surface representation, one would use *ɛ* for both.

(1)	*q̓ɛχ*	/q̓iχ/	[q̓ɛχ]	'younger sibling'
(2)	*č̓ɛgət*	/tʃʼagat/	[tʃʼɛgat]	'to help someone'

The degree and directionality of the effects of adjacent consonants on vowels have yet to be quantified. In this paper, we present the first detailed acoustic description of the Comox-Sliammon vowel system, specifically testing the effect of uvular and palatal consonants. From this, we confirm that vowel quality is largely predictable from context. We discuss how these findings have been useful in community-based discussion regarding the orthographic representation.

3. METHODOLOGY

As researchers working on an endangered language, our priority is to make the most of the limited time we have left to work with L1 speakers. One way to do this is to find multiple uses for existing recordings. The data used in this analysis were collected as part of ongoing efforts to document the language through an e-dictionary project.

3.1. Participants and Procedure

The recordings came from two fluent L1 speakers of ʔayʔaǰuθəm in their eighties, one female (EP), the other male (FL). The recordings were made in a quiet room with a Zoom H6N recorder and Lavaliere microphones at a 48kHz sampling rate. Up to three repetitions of each word were recorded.

3.2. Materials

396 tokens were analysed across 102 unique lexical items. There were 241 tokens from EP and 178 from FL. The words included each vowel (/a i u ə/) next to uvular (/q qʷ q' qʷ' χ χʷ/), palatal (/d͡ʒ t͡ʃ t͡ʃ' ʃ j/), and neutral (/t p θ s ɬ n m l/) consonants. Table 1 shows the distribution of vowels across the five conditions: uvular_neutral, neutral_uvular, palatal_neutral, neutral_palatal, and neutral_neutral. All vowels came from the initial syllable of a word, which bears primary stress, meaning all vowels are of similar prominence and duration [2]. Across the language, there are relatively few words where /u/ is followed by a palatal, which resulted in the small number of tokens for this condition (3 per speaker).

Table 1: Distribution of vowels across conditions

	/ə/	/i/	/u/	/a/	Total
uvular_neutral	28	17	19	19	83
neutral_uvular	26	20	17	18	81
palatal_neutral	27	22	24	17	90
neutral_palatal	18	24	6	28	76
neutral_neutral	23	28	13	25	89
Total	122	111	79	107	419

3.3. Analysis

Vowel onset and offset were marked and a Praat script was used to extract F1 and F2 values at seven points over the duration of the vowel (5%, 10%, 25%, 50%, 75%, 90%, 95%) [3]. Given the small sample size, we choose to use raw formant values and treat each speaker separately. We provide a descriptive analysis with confidence ellipses and intervals, but do not provide a statistical analysis. Data analysis and visualization was done using ggplot2 [7].

4. RESULTS

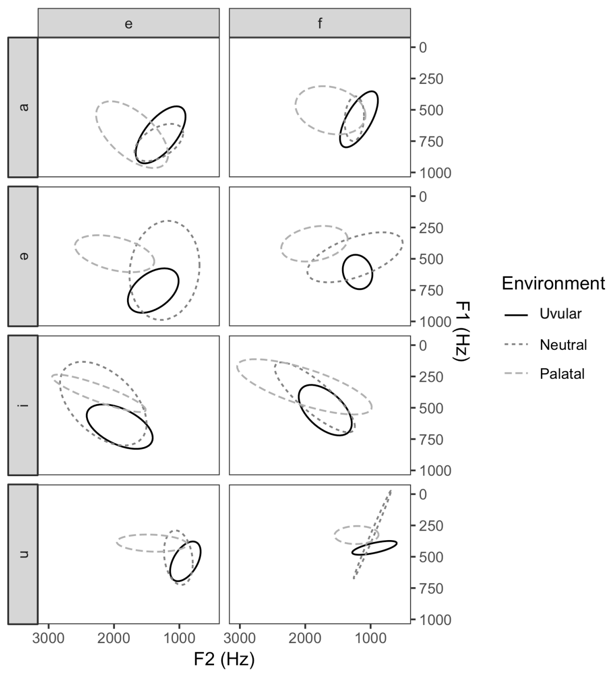
4.1. Midpoint Measurements (50% of Vowel Duration)

Vowel quality varies across environments. The confidence ellipses in Figure 1 show where 95% of measurements for midpoint F1 and F2 are predicted to fall for each environment. This is divided by speaker (e=EP, f=FL) and vowel. Midpoint is defined as 50% of vowel duration.

Vowels in palatal environments (neutral_palatal or palatal_neutral) have lower F1 and higher F2 values, consistent with raising and fronting. In uvular environments (neutral_uvular or uvular_neutral), vowels have higher F1 and lower F2 valeus, consistent with lowering and backing. This is true of both speakers.

The difference between a palatal and neutral context for /i/ is minimal, as is the difference between a uvular and neutral context for /a/ and /u/. Of the four vowels, /u/ appears to be the most distinct acoustically across all environments: though it is more front in a palatal environment, with F2 values similar to /ə/ and /a/, a low F1 places it in an otherwise unoccupied portion of the vowel space.

Figure 1: 95% Confidence Ellipses for F1 and F2 (Hz) at Vowel Midpoint (50%) for speaker EP (e) and FL (f), by Environment



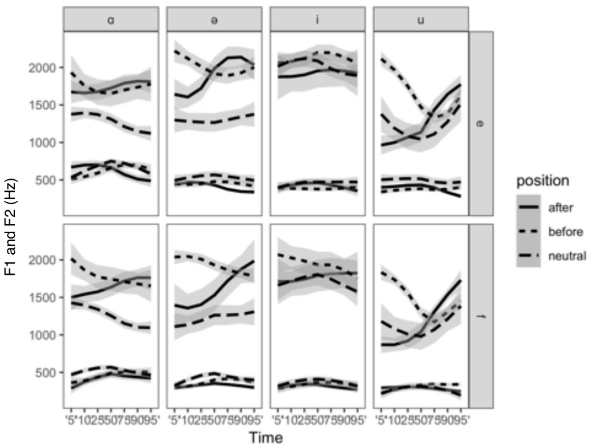
The other vowels are less distinct and fall in the mid-to-high front portion of the vowel space. Schwa (/ə/) shows the greatest susceptibility to conditioning effects: it shows drastic fronting in a palatal environment, bringing it close to /i/, and lowering in a uvular environment, bringing it close to /a/. While overlap between /ə/ and /i/ was expected [6], previous work does not report /ə/ being realized as low as [a]. It is worth noting that there is a considerable amount of overlap between the vowels for each individual speaker. This is particularly true of /ə/ and /a/, which are shown to occupy a similar acoustic space in Figure 1.

4.2. Vowel Trajectories

The vowel trajectories represent seven points over the duration of the vowel with a 95% confidence interval. In the palatal environment, the largest difference is seen in F2. This is shown in Figure 2, where F1 and F2 trajectories are plotted for palatal_neutral (before), neutral_palatal (after), and neutral_neutral (neutral) environments.

Figure 2 shows that the height of /i/ is comparable across palatal and neutral conditions. The same is true of /u/ for FL, though EP has lower F1 values in the palatal environment. The position of the palatal consonant does not make a difference.

Figure 2: F1/F2 trajectories in palatal (before and after) and neutral environments (EP = e, FL = f)



At onset (5%), the height of /ə/ is similar across conditions. For both speakers, F1 is lowest when a palatal follows and this effect increases over the duration of the vowel. In contrast, /a/ trajectories differ by speaker. A following palatal is associated with a decline in F1 over the duration of the vowel for EP. For FL, the F1 of /a/ is lower following a palatal consonant, but is otherwise comparable to other conditions, particularly at vowel offset (95%).

High vowels are minimally affected by a palatal consonant, with /i/ showing little difference between environments. A preceding palatal results in a higher F2 for /u/ at vowel onset, though a following palatal does not make a substantial difference. In contrast, the F2 trajectories of the other vowels are substantially different. Both speakers have higher and categorically discrete trajectories for /a/ and /ə/ in a palatal environments. The /a/ and /ə/ F2 trajectories for FL appear to be affected more by a preceding palatal than a following one, while a palatal consonant on either side of /a/ or /ə/ is associated with higher F2 values for EP.

Figure 3 shows F1 and F2 trajectories for vowels adjacent to a uvular consonant with a 95% confidence interval. Though /i/ showed little difference in the palatal environment, an adjacent uvular consonant has a clear effect. For both speakers, F1 trajectories for /i/ are higher beside a uvular, particularly at the transitions (5% and 95%).

In both neutral and uvular environments, EP has similar F1 values for /u/, while FL has higher and categorically discrete F1 trajectories for /u/ next to uvulars, highlighting a difference between speakers.

F1 values for /ə/ are higher at vowel onset after a uvular and higher at offset when before a uvular for both speakers. The trajectories show the anticipated conditioning effect of the adjacent vowel on either side, while the neutral trajectory is relatively stable. However, the position of the consonant does make a difference for /a/. Before a uvular consonant, offset F1 values are higher. Trajectories for /a/ following a uvular consonant are similar to those in the neutral condition.

Figure 3: F1/F2 trajectories in uvular (before and after) and neutral environments (EP = e, FL = f)

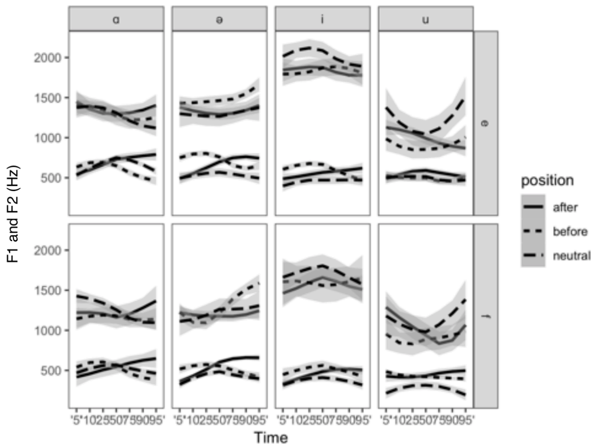


Figure 3 also shows that F2 trajectories in the uvular and neutral conditions largely overlap, which suggests that uvular consonants mostly affect height and only have a minimal influence on frontness. The exception to this is /u/, which does have considerably lower F2 values in the uvular condition than the neutral one for both speakers.

5. DISCUSSION

5.1. Effects of Palatal and Uvular Consonants

The predicted effects of palatal and uvular consonants were found for each of the vowels and for both speakers. Palatal consonants are associated with higher and more front vowels, while uvular consonants are associated with lower vowels. Overall, palatal consonants have a greater influence on F2 values. This was particularly true when the vowel follows the palatal consonant.

Uvular consonants had a greater effect on F1, particularly when the consonant followed the vowel.

However, the height of /u/ varied by speaker in this condition. EP showed no evidence of lowering, while FL had categorically discrete trajectories. Of the vowels, /ə/ exhibits the most variation. In both palatal and uvular conditions, the trajectory was distinct from the neutral condition.

5.2. Implications for the Writing System

We conclude, based on acoustic evidence, that variation in ʔayʔaǰuθəm vowel quality is largely predictable; F1 and F2 values vary for each vowel at different timepoints, consistent with previous impressionistic descriptions of vowel quality in palatal and uvular environments.

Exploring these effects using acoustic data has been useful for differentiating the systematic differences in surface vowel quality from less predictable inter-speaker and intra-speaker variation. The latter raises an issue because the writing system privileges surface form: if speaker A says the words in (3) and (4) with [ɛ] (orthographic *ɛ*) and speaker B uses [ɪ] (orthographic *ι*), how should the morpheme be written in the dictionary? Further, what should the spelling be if speaker A produces [ɛ] in one repetition and [ɪ] in another?

(3) m̓əm̓t̓**oθɛn** ~ m̓əm̓t̓**oθιn** ‘to have food on face’
(4) ƛ̓aƛ̓ʔ**oθɛn** ~ ƛ̓aƛ̓ʔ**oθιn** ‘to interpret’

The words in (3-4) each have the suffix /-uθin/ ‘mouth’, which is variably realized with either [ɛ] or [ɪ]. Though vowel quality is predictable adjacent to palatal and uvular consonants (meaning that /a/ can straightforwardly be written as ɛ next to a palatal consonant), the variation between [ɛ] or [ɪ] in this “elsewhere” condition is not systematic. When using a surface-based orthography, this type of unconditioned variation poses a problem when trying to establish a constant spelling for the same morpheme across different lexical items and speakers.

Acoustic data has proven useful for explaining how the vowels vary in predictable and unpredictable ways. Vowel formants can be plotted for different speakers and words, allowing members of community to see visual representations of the vowel space. The data in this paper were shown to members of the dictionary team to explain the relationship between the phonetic realization, underlying forms, and orthographic representation. They then settled on a single spelling for morphemes with variable pronunciation, becoming more comfortable in representing conditioned vowel changes consistently (such as the palatal and uvular effects described in this paper), and choosing a common representations for unconditioned variation (such as that between [ɛ] and [ι]) on a morpheme by morpheme basis. Once orthographic decisions are made, they are then implemented across all instances of a given morpheme. For instance, the community decided to represent the suffix in (3-4) consistently as *-oθɛn*. This systematic spelling makes dictionary work more efficient and assists learners in recognizing the same morpheme across lexical items. The dictionary will still include a range of documented (and equally correct) pronunciations in the form of audio examples from multiple speakers.

In contrast, conditioned effects associated with a palatal or uvular consonant are predictable and can be represented in the orthography if learners are taught to recognize systematic patterns associated with vowel quality. Acoustic data can be used to demonstrate how pronunciation and orthography relate to underlying vowels.

From a linguistic perspective, this work is also useful for understanding ʔayʔaǰuθəm grammar. For example, an ablaut process marks plurality (e.g. *k̓apat* ‘to cut something/multiple things up’ from *k̓əpt* ‘to cut’), but is sometimes hard to identify in spontaneous speech. Knowing how the adjacent consonants can affect vowel quality is a useful diagnostic for identifying ablaut and similar morphological processes that involve differences in vowel quality. Understanding the systematic relationship between underlying and surface forms is therefore beneficial both for linguists and for adult language learners.

6. CONCLUSION

We confirm that variation in vowel quality in ʔayʔaǰuθəm is predictable. Systematic description and illustration of the vowel space is not only crucial for linguistic analysis, but is also important in informing decisions about spelling in a community-driven ʔayʔaǰuθəm dictionary project. Importantly, we conclude that phonetic analysis provides information that facilitates language revitalization efforts.

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