The Rhythm of Hul’q’umi’num’*

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Abstract: This research explored the linguistic rhythm of Hul’q’umi’num’, based on the audio recording of a story told by a Hul’q’umi’num’ Elder. The story was segmented into consonant and vowel intervals; rhythm was calculated by applying a number of standard metrics to the segmented file. According to vocalic metrics (%V, ΔV, and VarcoV), Hul’q’umi’num’ patterned in the same rhythmic category as English (‘stress-timed’). This was expected, given that Hul’q’umi’num’ exhibits a number of features said to be typical of stress-timed languages. According to consonantal metrics (ΔC and VarcoC), Hul’q’umi’num’ patterned like no other documented language. This is likely reflective of the important role that consonants play in Salish languages. This study contributes to our understanding of rhythm cross-linguistically, and serves as a baseline for understanding the rhythmic differences between first and second language Hul’q’umi’num’ speakers, and what teaching strategies we might develop to support second language learners to achieve fluent pronunciation.

Keywords: Hul’q’umi’num’, phonetics, rhythm

1 Introduction

Salish languages have rich sound systems, with many consonants not found in English. In addition, consonants are often strung together in long sequences, often as a result complex morphological concatenation. These consonantal sequences give Salish languages a unique rhythm, which has yet to be thoroughly documented. In this paper, we report on a study of Hul’q’umi’num’ rhythm, based on a recording of a single speaker, Bernard David (Tl’isla), from Stz’uminus, telling a story about his career as a canoe puller to his granddaughter Margaret Seymour and linguist Donna Gerdts in Duncan, BC, on November 28, 2017. Delores Louie and Ruby Peter translated the story and Ruby Peter and Donna Gerdts then transcribed it to the phonemically-based system currently used for Hul’q’umi’num’ materials.[1]

A portion of the story was segmented and phonetically transcribed using acoustic analysis software. Rhythm was quantified by applying a number of

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‘rhythm metrics’ to the segmented file. According to metrics reflecting vocalic content, Hul’q’umi’num’ patterned similarly to English and other so called ‘stress-timed’ languages. According to metrics reflecting consonantal content, Hul’q’umi’num’ patterned like no other documented language. We interpret these findings in reference to the literature on rhythm cross-linguistically, and discuss their implication in the context of Hul’q’umi’num’ language revitalization.

In the remainder of the paper, we provide relevant background (Section 2) on Hul’q’umi’num’ sound structure (2.1) and rhythm (2.2); we describe the methodology used to segment the recording and analyze its rhythm (Section 3); we present the results of this study (Section 4); and we discuss the contribution of this study to Salish language documentation and revitalization efforts (Section 5).

2 Background

2.1 Hul’q’umi’num’ sound structures

Salish languages have very simple vowel inventories. In Hul’q’umi’num’, there are five vowels (/i e ə a u/), four of which contrast for length (long vs. short, excluding /ə/). As is typical in Salish languages, /ə/ can be stressed; in this case it is generally realized as /ʌ/ (Parker, 2011).

In contrast, Salish languages have among the most complex consonant inventories in the world. As shown in Table 1 below, Hul’q’umi’num’ has ten “back-of-the-mouth” sounds (which translate to IPA /k k^w k̓^{w} q q̓ q ^{w} q̓^{w} x^w x̌ x̌^{w}/) whereas English only has two (/k g/). These sounds contrast in various ways: location (velar /k/ vs. uvular /q/), manner (plosive /q/ vs. fricative /x/), lip rounding (plain vs. labialized, e.g. /q/ vs. /q^w/), and voicing (plain vs. ejective, e.g. /q/ vs. /q̓/). Hul’q’umi’num’ also contains a complex set of coronal fricatives and affricates (/θ tθ tθ’ ł / ƛ̓ s c c’ š č č’/), including a lateral sounds (/ł/ and / ƛ̓/). Also unusual is that resonants (/m n l w y/) can be plain or glottalized (e.g. /m/ vs. /m̓/). (See http://sqwal.hwulmuhwqun.ca/learn/learning-the-sounds/ for basic descriptions and examples.)

Table 1: Hul’q’umi’num’ consonant inventory (using APA)

p		t			k	k^w	q	q^w	ʔ
p̓		t̓				k̓^{w}	q̓	q̓^{w}	
	t^θ	c		č					
	t̓^{θ}	c̓	ƛ̓	č̓					
	θ	s	ł	š		x^w	x̌	x̌^{w}	h
m		n	l	y		w			
m̓		n̓	l̓	y̓		w̓			

Not only does Hul’q’umi’num’ have many consonants, they can also be strung together in long sequences, often as a result of morphological concatenation. Hul’q’umi’num’ is a polysynthetic language (Gerdts & Werle, 2014), which makes use of hundreds of affixes and clitics. Each of these can contain multiple consonants; some contain no vowels; and, there are generally no breaks between them. In short, the morphological complexity of Hul’q’umi’num’ adds to its phonological complexity. The following examples illustrate typical Hul’q’umi’num’ words and phrases:

(1) Complex consonant clusters in Hul’q’umi’num’ words (clusters are bolded).

xʷθtiwən	‘think’
t̓q̓wit̓ᶿeʔe**łcθ**	‘slice it for me’
kʷakʷəxwə**w̓txw**ə**łcθ**am̓š	‘knocking on the house for me’
θə**yt ct c**eʔ	‘we will fix it’

Summarizing, Hul’q’umi’num’ has a broad consonantal inventory and a small vocalic one. It makes extensive use of affixes and clitics, all of which create long strings of consonants. The phonemic make-up of the language (consonants and vowels) and the way these phonemes are strung together create a rhythmic flow that is quite unique, when we compare it to that in other, previously documented languages.

2.2 Rhythm

Languages such as French or Italian have a distinct flow from languages like English or Dutch, and this difference has generally been attributed to what linguists call ‘rhythm’. This section will introduce rhythm, evaluate its reality as a psychological phenomenon, and identify metrics used to quantify it from a speech sample.

James (1940) was the first to describe cross-linguistic rhythm differences, contrasting ‘machine-gun rhythm’ (French) and ‘morse code rhythm’ (English). Early analyses of rhythm assumed that machine gun rhythm resulted from regularly repeating, or *isochronous*, syllables, whereas morse code rhythm resulted from isochronous stresses (Pike, 1945; Abercrombie, 1967). Later on, the mora was added to the set of possible isochronous units (Trubetzkoy, 1969). The basic classes of rhythm were therefore established to be syllable-timed, stress-timed, and mora-timed.

In support of traditional rhythm classes, perception studies have shown that both newborns and adults can distinguish between dialects/languages of different rhythm classes but not between languages of the same rhythm class (Nazzi, Bertoncini & Mehler, 1998; Ramus, Dupoux & Mehler, 2003; Rathcke & Smith, 2015). The production facts are less clear though: studies like Dauer (1983) have shown that stresses in English (stress-timed) are no more isochronous than stresses in Spanish (syllable-timed). Based on her work, Dauer concluded that rhythm should be thought of as a ‘total effect’ involving multiple phonetic and phonological phenomena. According to her, two key properties distinguishing syllable-timed and stress-timed languages are syllable structure and vowel reduction: Stress-timed languages tend to have more variety in syllable types than do syllable-timed languages, including syllables with consonant clusters; they also tend to have vowel reduction in unstressed syllables. These two properties lead to relatively more irregularity in syllable composition and duration in stress-timed than in syllable-timed languages. Building on her earlier work, Dauer (1987) further argued that languages are more or less stress-timed or syllable-timed (along a continuum) depending on how many phonetic and phonological features they have that are typical of stress-timing vs. syllable-timing.

Recognizing the psychological reality of rhythm while moving past the theory of isochrony, several metrics have been developed to classify languages by their rhythm class, all based on durational measures which are meant to correlate with more abstract phonological properties (such as syllable complexity and vowel reduction introduced above). They include ΔV, ΔC, and %V (Ramus, Nespor & Mehler, 1999); VarcoV and VarcoC (Dellwo, 2006); and various PVI measures (Grabe & Low, 2002).

Ramus et al. (1999) proposed three rhythm metrics – ΔV, ΔC, and %V[2]: ΔV reflects the variability in duration of vocalic intervals within an utterance, quantified as standard deviation. Similarly, ΔC is the standard deviation of consonantal intervals within an utterance. %V is the proportion vocalic content within an utterance. Using these metrics, Ramus et al. analyzed four adult speakers reading five sentences in each of English, Dutch, Polish, (stress-timed); French, Spanish, Italian, Catalan (syllable-timed); and Japanese (mora-timed). They found that these three rhythm classes had significantly different scores for ΔC and %V, but not for ΔV. Their results supported Dauer's (1983, 1987) claims about the key role of syllable structure: typically, syllables gain weight by gaining consonants. Therefore, the more syllable types present in a language, the greater the variability in the number of consonants and in their overall duration within the syllable, resulting in a higher ΔC. A higher number of syllable types also implies a higher C to V ratio, and as a result a lower %V. Ramus et al. point out that ΔV is influenced by vowel reduction, contrastive vowel length, vowel lengthening, and long vowels. These factors, and consequently ΔV, can be affected by speech rate, making ΔV a less reliable measure than ΔC and %V.

Dellwo (2006) (as cited in White and Mattys, 2006) further showed that ΔV and ΔC vary considerably as a function of speech rate. Building on Ramus et al.'s (1999) work, Dellwo proposed variation coefficients VarcoΔC and VarcoΔV, known as simply VarcoV and VarcoC, respectively. These metrics take speech rate into consideration, which Ramus et al. (1999) failed to do. Ordin and Polyanskaya (2015) also utilized another, similar, Varco metric: VarcoS (where S refers to syllables). Dellwo (2006) confirmed that VarcoC gave a clearer discrimination than ΔC, at various speech rates, between stress-timed languages (English and German) and syllable-timed languages (French) (as cited in White & Mattys, 2006). VarcoV also proved to better differentiate rhythm classes than ΔV.

The pairwise variability index (PVI) is another rhythm metric that was introduced by Low et al. (2002). They developed it based on Dauer's (1983) finding that stress-timed languages tend to have vowel reduction, whereas

[2] %C is isomorphic to %V therefore it does not need to be considered.

syllable-timed languages tend not to. The PVI included only vocalic intervals (PVI-V), specifically to reflect the alternations of longer and shorter vowels in successive pairs within an utterance. Low et al. investigated the rhythm of British English, which is said to be stress-timed, and Singapore English, which is said to be syllable-timed, using this metric. Overall, they found that durational variability was greater (reflected in a greater PVI-V score) in British English than in British English, meaning that successive vowel intervals were more equal in duration in Singapore English than in British English. Low et al. concluded that in this case, PVI distinguished between syllable- and stress-timed languages better than metrics proposed by Ramus et al. (1999). Later on, the PVI metric was extended to be raw (rPVI) or normalized with speech rate (nPVI) and applied to consonants (nPVI-C, rPVI-C), vowels (nPVI-V, rPVI-V) or syllables (rPVI-S, nPVI-S) (Grabe & Low, 2002; Ordin & Polyanskaya, 2015).

As Grabe and Low (2002) point out, the predictions of the metrics introduced above are not fully clear. A given language might be placed in different classes based on the output of different metrics. Metric scores are further influenced by variation in materials, speaking styles, speech rate, and speaker identity. These factors may influence metric scores more than rhythm class affiliation. In addition, factors responsible for stress-timed and syllable-timed rhythmic templates still have not been reliably identified.

Salish languages' consonantal segments vary considerably in inherent duration, and their words contain a wide range of syllable types, including frequent consonant clusters (see (1) above). It is therefore predicted that they will pattern more like stress-timed languages than like syllable-timed languages. Since Salish rhythm has not yet been documented (as far as we know), we hope that this project will lead us to a better understanding of what factors contribute to perceived rhythm across languages. More practically, understanding the rhythmic properties of Hul'q'umi'num' will help us to teach rhythm to learners, who take very seriously their responsibility to speak in a way that honours their Elders' speech (c.f. Bird & Kell (2017)).

3 Methods

For this study, Mackenzie Marshall segmented a portion of the story (3.54 minutes; 13 sentences) and transcribed it phonetically, using the spectrogram and waveforms for reference (see Figure 1). Segmentation was done using Praat (Boersma & Weenink, 2017), following guidelines from Bird, Wang, Onosson, & Benner's (2015) *Acoustic Phonetics Lab Manual*. Methods for phoneme segmentation and consonant/vowel rhythm segmentation were guided by Ramus et al. (1999), Grabe and Low (2002), and Payne et al. (2012).

Textgrid annotation was used for the segmentation (see Figure 1): Tier 1, 'CV Tier 1' of the textgrid was divided into consonant (C) and vowel (V) intervals, which were used in the rhythm calculations. In this Tier and subsequent ones, pauses and hesitations were annotated with <S> and excluded from the calculations. On Tier 2, 'Merged Cs', the same intervals were included but the actual vowels and consonants were listed for reference, rather than just <V> or <C>. Tier 3, 'Phonetic Tier', further segmented the intervals from Tiers 1 and 2;

specifically, on Tier 3, we segmented individual consonants and vowels, rather than intervals of adjacent sequences of consonants or vowels (e.g. <lhl> corresponded to two intervals on Tier 3 (|lh|l|) but only one on Tiers 1-2 (|lhl|). Tier 4 'Phonetic Phrase' and Tier 5 'Orthographic' were for comparing our phonetic transcription to the phonemically-based transcription that Ruby Peter and Donna Gerdts provided with the story.

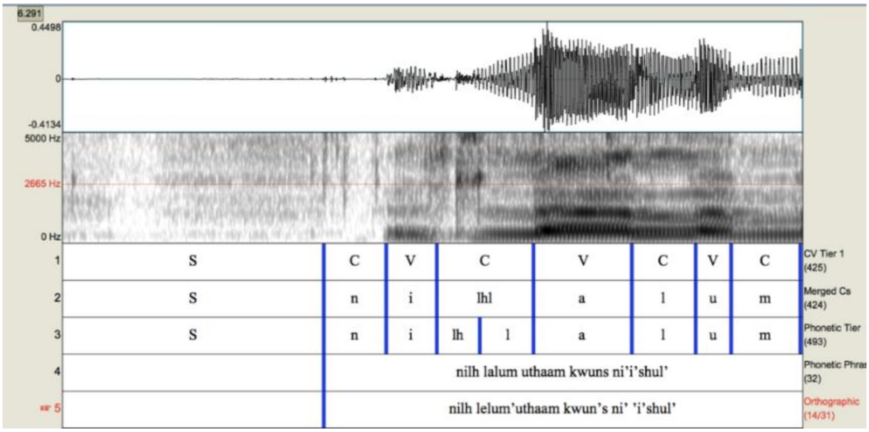

Figure 1: Praat segmentation method.

The rhythm metrics that were calculated included %V, ΔV, ΔC, VarcoV, and VarcoC. A Praat script automatically calculated each of these metrics based on the durational information available through the segmented and labelled Textgrids (see Figure 1). This script was based on White and Mattys' (2007) script.

4 Results

The results consist of the values for each metric, generated by the Praat script mentioned above: %V was 38.638, ΔV was 55.76, ΔC was 87.713, VarcoC was 59.64, and VarcoV was 52.64. There are no exact numbers that indicate stress-timing vs. syllable-timing; therefore, these metrics on their own are not strong indicators of rhythm class. However, when compared to those from other languages, these metrics can tell us about relative rhythm and classification. Language data points for English, Dutch, French, and Spanish in Table 2 below were sourced from White and Mattys (2007). Our measures of Bernard's Hul'q'umi'num' are added to the table, for comparison.

Table 2: Rhythm metrics across languages

Metric	Spanish	French	English	Dutch	**Hul'q'umi'num'**
%V	48	45	38	41	39
VarcoV	41	50	64	65	53
VarcoC	46	44	47	44	**60**
ΔV	32	44	49	49	56
ΔC	40	51	59	49	**88**

This data is projected in the figures below, including %V x ΔC (Figure 2), %V x VarcoC (Figure 3), %V x ΔV (Figure 4), %V x VarcoV (Figure 5), and VarcoV x ΔC (Figure 6). These projections were chosen based on previous literature (Ramus et al., 1999; White & Mattys, 2007, Ordin & Polyankskaya, 2015).

Figure 2 plots data across languages over the (%V, ΔC) plane. Languages grouped more on the left (English, Dutch) represent the stress-timed language class while languages on the right (French, Spanish) represent syllable-timed classes. Hul'q'umi'num' sits above either class according to ΔC, but patterns like English and Dutch according to %V.

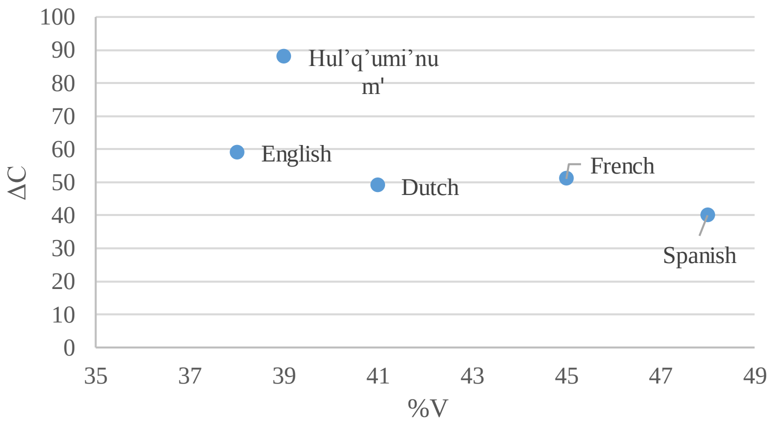

Figure 2: Distribution of languages over the (%V, ΔC) plane.

Figure 3 plots data from languages over the (%V, VarcoC) plane. No obvious grouping presents itself in the figure, except perhaps that languages go from stress-timed on the left to syllable-timed on the right due to the %V metric. Hul'q'umi'num' has a high VarcoC value (59.64) which distinguishes it from other languages.

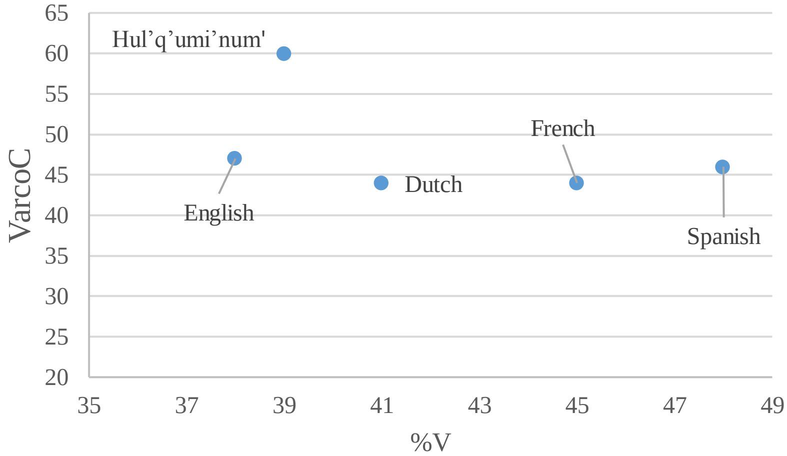

Figure 3: Distribution of languages over the (%V, VarcoC) plane.

Figure 4 plots data from languages over the (%V, ΔV) plane. Languages grouped more on the left (English, Dutch) represent the stress-timed language class while languages on the right (French, Spanish) represent syllable-timed classes. Hul’q’umi’num’ fits well with other stress-timed languages according to these metrics.

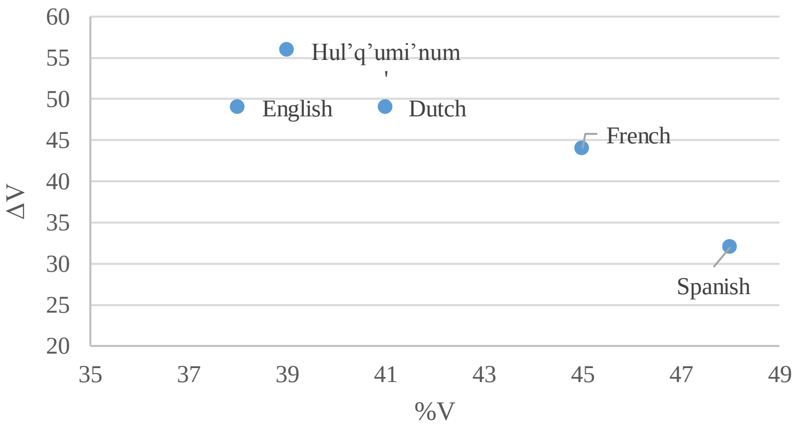

Figure 4: Distribution of languages over the (%V, ΔV) plane.

Below, Figure 5 shows the projection of data from languages over the (%V, VarcoV) plane. Very similar to Figure 4, languages grouped more on the left (English, Dutch) represent the stress-timed language class while languages on the right (French, Spanish) represent syllable-timed classes. Hul’q’umi’num’ fits well with other stress-timed languages according to these metrics.

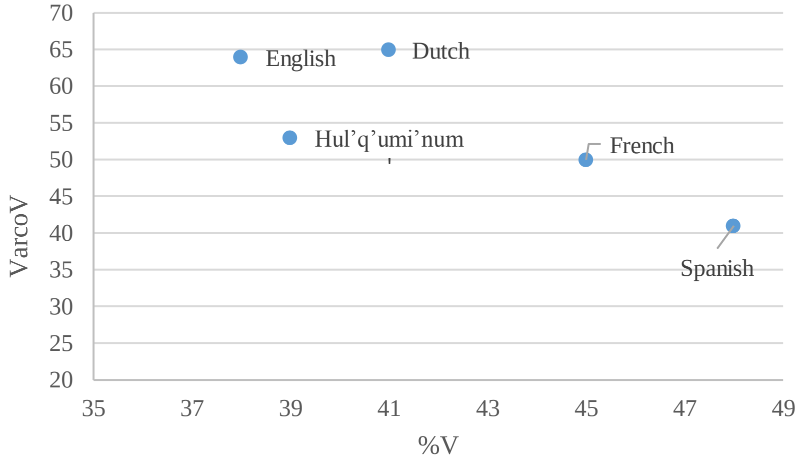

Figure 5: Distribution of languages over the (%V, VarcoV) plane.

Finally, Figure 6 shows the projection of data from languages over the (VarcoV, ΔC) plane. Languages grouped tightly on the right (English, Dutch) represent the stress-timed language class while languages in the lower left (French, Spanish) represent syllable-timed classes. Hul'q'umi'num' does not group clearly with either class, and instead sits above both of them

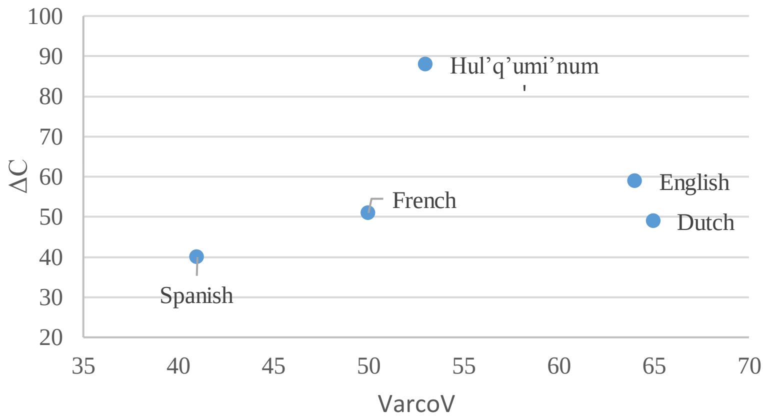

Figure 6: Distribution of languages over the (VarcoV, ΔC) plane.

Overall, according to vowel-based metrics, Hul'q'umi'num' rhythm was consistent with other stress-timed languages. On the other hand, consonant-based metrics placed Hul'q'umi'num' as more of a rhythm-class outlier.

5 Discussion

Figures 4 and 5 figures both involved only vocalic measures, %V, ΔV, and VarcoV. While these suggest that Hul'q'umi'num' patterns with other stress-timed languages, this classification warrants further consideration. Like English, Hul'q'umi'num' has vowel reduction in unstressed syllables. English has many diphthongs (e.g. /ei/), which are substantially longer than monophthongs in duration; similarly, Hul'q'umi'num' contrasts short and long vowels. It is not surprising then that Hul'q'umi'num' and English pattern similarly to one another based on vocalic metrics. However, Figures 2, 3, and 6 show that when consonantal intervals are considered, Hul'q'umi'num' patterns like no other language included in White and Mattys (2007). Hul'q'umi'num' consonants can vary significantly in inherent duration (e.g. glottal stop vs. /s/), as well as in how many are included in a given syllable (e.g. VCV vs. VCCCCV). Naturally, ΔC and VarcoC reflect this variation, with values diverging substantially from those in the other languages illustrated here (VarcoC = 87.71, ΔC = 59.64). This drastic variation in consonantal intervals sets Hul'q'umi'num' apart from other languages on the rhythm continuum. Indeed, it appears that Hul'q'umi'num' lies outside the rhythm spectrum entirely, based on consonantal metrics. This finding likely reflects the important role that consonants play in Hul'q'umil'num' (relative to vowels), and in Salish language more generally. It also suggests that we would benefit from studying a broader range of languages than has so far been considered, including Indigenous languages of the Pacific Northwest, if we are to truly understand the typology of rhythm.

Recall that we had access to a phonemically-based transcription of the story, in addition to the phonetic transcription we came up during our segmentation work. The phonemically-based transcription was done by language experts, with no particular expertise in phonetics. The phonetic transcription was done by phoneticians, with little prior knowledge of Hul'q'umi'num'. Interestingly, we found many differences between the two transcriptions, including ones which would likely affect rhythm metrics, such as consonant cluster reductions and vowel elisions. One particular difference between phonemically-based and phonetic transcriptions involved glottal stop, which often seemed absent phonetically in places it was transcribed phonemically. For example, and similarly to what has been found in neighbouring SENĆOŦEN (Bird, Leonard & Czaykowska-Higgins, 2012), *full vowel-glottal stop-schwa* sequences were often realized as a long vowel, e.g. <a'u> → [a:]. The absence of expected glottal stops would have affected consonantal variability metrics (VarcoC and ΔC), as well as %V and VarcoV in cases where compensatory vowel lengthening occurred. Certainly a closer look at the discrepancies between phonetic and phonemic transcriptions would increase our understanding of the mechanics of spontaneous speech production, which have been studied in widely spoken languages like English (e.g. Warner & Tucker, 2011) but not in Salish languages, as far as we know.

The question of how spontaneous speech is realized also relates to second language acquisition of rhythm, in terms of the differences in how first and second language speakers pronounce Hulq'umi'num' words and phrases. Since rhythm –

as currently defined in the field – is a function of how consonants and vowels combine in speech, learners must be able to master both the morphology (i.e., use all the appropriate morphemes in constructing their sentences) and the phonology (i.e., pronounce the consonant clusters within these morphemes, without inserting excrescent vowels), if they are to get the rhythm right. The quantification of rhythm that we undertook in this study can act as a baseline in future work studying rhythm among second language learners of Hul'q'umi'num', to determine (a) how it may differ from that of first language speakers in a holistic sense, and (b) what specific pronunciation features (e.g. insertion of schwa to break up consonant clusters; absence of key (consonantal) morphemes) might be responsible for broader rhythmic differences. Since rhythm itself is quite difficult to teach (Ordin & Polyanskaya, 2014), focusing on more concrete pronunciation features that we know contribute to rhythm (e.g. schwa-less consonant clusters) can potentially be quite successful as a pronunciation teaching strategy, to help learners achieve fluent pronunciation.

6 Conclusion

This study was the first that we know of to document the linguistic rhythm of a Salish language. Through applying standard rhythm metrics to a Hul'q'umi'num' story, we discovered that, while Hul'q'umi'num' patterned like other stress-timed languages according to vocalic metrics, according to consonantal metrics, it stood out distinctly from other typical stress-timed and syllable-timed languages. From a practical stand-point, our study has provided a baseline for investigating learners' Hul'q'umi'num', and developing appropriate materials and resources for teaching rhythm in the context of language revitalization.

This project was a case study, of a 3.5 minute clip of a story told by a single speaker and a single language. This being the case, there are many possibilities in terms of future work that builds on the project. In terms of rhythm typology, studying longer recordings with additional speakers, across Salish languages, will give us a better sense of what features make up Salish languages' unique rhythm, as well as what features, in general, contribute to rhythm cross-linguistically.

In terms of rhythm acquisition, comparing the metrics calculated here with those of second language Hul'q'umi'num' learners would help us to know what rhythm-related features differ between first and second language speakers, and consequently how to best support second language speakers in achieving the same rhythmic flow as their Elders. For example, Ordin and Polyanskaya (2015) have shown that second language learners initially speak with syllable-timed rhythm, regardless of the rhythmic properties of their first language or of the language they are learning, and in fact some Hul'q'umi'num' learners start with syllable-timing (Donna Gerdts, personal communication). So the question is, (how) can they be supported to progress to stress-timing, for example by encouraging them paying closer attention to their articulation of consonant clusters, and to consonants more generally.

Finally, this project has opened the door to a more thorough investigation of how the phonetic realization of Hul'q'umi'num' is connected to its morphological structure. This is an area we hope to continue exploring in our future, collaborative work.

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