AN ACOUSTIC ANALYSIS OF RHYTHM IN BAHDINI KURDISH

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ABSTRACT

Based on their common rhythmic characteristics, languages have been divided into different classes: stressed-, syllable- and mora-timed languages. A variety of studies have examined the acoustic correlates of rhythm in various world languages. However, there has not yet been any experimental work analysing the rhythmic properties of Kurdish, nor is it clear to which rhythmic class it belongs. This study examines the acoustic correlates of rhythm in one of the sub-dialects of Kurdish, namely Bahdini Kurdish (BK). It represents the first attempt to study BK rhythmic patterns using the methods proposed by Ramus et al. (1999) to analyse rhythm metrics. The study is based on the reading of 10 BK sentences and the spontaneous speech of 10 BK native speakers. The data was segmented using the speech analysis program Praat and the duration of the vowel and consonant intervals was derived. The rhythm class of BK was determined by examining the patterns of duration, variability and segmental properties, and then the effects of speakers and speaking styles on the variation of the rhythm metrics were examined. The results show that the rhythmic quantitative features of BK are associated with syllable-timed languages in both read and spontaneous speech. Both the speaker and speaking style were observed to have an effect on the values of %V. The study contributes to filling a gap in phonological studies of BK by examining the segmental-prosodic profile of the language to determine whether it correlates with a stress-timed or syllable-timed rhythm-metric composition. Providing BK's rhythm-metric computations also expands the existing repository of languages already explored using this framework.

Keywords: Bahdini Kurdish, rhythm, stressed-timed, syllable-timed, segmental intervals, speaking styles

INTRODUCTION

Rhythm is a prosodic feature that results from the repeated intervals that occur successively in human speech and depends on certain factors such as syllable structure, the contrasts of short and long vowels, vowel reduction, and the appearance/absence of vowel sequences (Ladefoged 2006). Languages can be divided into three different classes based on their rhythm characteristics: stressed-timed, syllable-timed and mora-timed.

This study will analyse the rhythmic properties of Bahdini Kurdish (BK) and identify the rhythmic class to which the language belongs. BK is a subdialect of the northern Kurmanji dialect of Kurdish, which belongs to the Indo-European language family. It is a member of the northwestern subgroups of Iranian languages, which are subdivisions of the Indo-Iranian branch of this largest language family in the world (Thackston 2006). The language is divided into three main groups: Northern, Central and Southern Kurmanji, in addition to Dimili and Hewrami (Kurdish Academy of Language 2023). BK is spoken in the cities of the Duhok Governorate in the north of Iraq. As for the phonemic system, BK has eight vowels (Khan and Salih 2017) and 32 consonants (Hasan 2012). Four vowels – /iː, uː, eː and ɑː/ – are inherently long and the others – /ɨ, ʉ, o and ɑ/ – are short. There is a debate about the existence of diphthongs in BK. For consonants, there is a phonological contrast in BK between aspirated and non-aspirated voiceless plosives and affricates (in terms of syllable initial position only) (Shokri 2002; Thackston 2006) as well as between palatalized and non-palatalized alveolar plosives.

BK does not have a complicated syllable structure. It has few syllable types and the consonant clusters can include up to two segments in the initial and final parts (Shokri 2002; Hasan 2009). The vocalic element is the central obligatory element in a syllable, while the non-vocalic elements are optional (Marif 1976; Shokri 2002). Shokri (2002) identifies the following syllable patterns for BK: V, VC, CV, CCV, CVC, CCVC, CVCC, VCC and CCVCC (V stands for vowel and C for consonant). However, vowel-initial syllable structures are not allowed in BK either word-initially or medially, because they are pronounced with a glottal stop that is not part of the phonemic structure of the syllable, i.e., not a true consonant but rather inserted to fill the onset position (Hasan and Mohammed 2023). Additionally, the stress in BK is almost always word-final, i.e. the stress is assigned to the last syllable of the

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prosodic word after all morphological operations have taken place (Hasan 2016).

Bahdini Kurdish has never been rhythmically studied, nor is it clear which rhythm class it belongs to. There is a study on the rhythm class of Kalhori Kurdish, a subcategory of Kurdish spoken in the southern part of the Kurdish language-speaking area in western Iran (Taghva and Zadeh 2016). Taghva and Zadeh (2016) analysed the rhythmic features of Kalhori Kurdish using Pairwise Variability Index (PVI) metrics and, based on the results, classified this variety of Kurdish within the stress-timed category. This study presents an analysis of BK's rhythm metrics to examine whether the language exhibits patterns of durational variability and segmental proportions typical of stressed-timed or syllable-timed languages. In addition, the effects of speakers and speaking styles on these metrics are examined. Specifically, we assume that: 1) if there is high alternating variability in the length of consonantal (C-) and vocalic (V-) intervals, then BK can be categorized as a stressed-timed language; 2) if there is low alternating variability in segmental intervals, it can be categorized as a syllable-timed language and 3) the durational metrics may vary depending on the speaker and speaking style.

The research questions that the study addresses are:

1) What are the rhythm patterns in BK?
2) Is there variability among speakers and speaking styles in the realization of the rhythm metrics?

The study is significant because it helps fill a gap in our understanding of the phonology of BK and examines the segmental-prosodic profile of the language to determine whether it is associated with a stressed-timed or syllable-timed rhythm-metric composition. The study complements the collection of studies that have used this approach on other languages by providing rhythm-metric calculations for a previously unanalysed language.

THE STUDY OF LINGUISTIC RHYTHM

According to the traditional isochrony hypothesis (Abercrombie 1967; Pike 1945), languages can be classified into syllable-timed, stress-timed and mora-timed. This grouping is attributed to the isochrony or equal duration of specific prosodic elements: syllables in the case of syllable-timed languages such as Spanish, Italian and French; stress intervals in the case of stressed-timed languages such as English and Dutch; or mora in mora-timed languages such as Japanese and Tamil. A variety of instrumental studies have shown that the stressed-based and syllable-based isochrony is not systematic and, furthermore, the empirical evidence for these classes is weak (Roach 1982; Dauer 1983).

Given the lack of phonetic evidence for the strong version of the traditional isochrony hypothesis, an alternative account of speech rhythm has been proposed, often going under the heading "rhythm class hypothesis" (e.g., Dauer 1983; Ramus et al. 1999). In this view, the perceived rhythm of the supposedly stress- and syllable-timed languages is reinterpreted as reflecting a combination of phonological and phonetic properties, particularly syllable structure and vowel reduction. Accordingly, stressed-timed languages tend to have a greater variety of syllable types and stress is correlated with syllable weight, while syllable-timed languages tend to have fewer syllable types and stress and syllable weight are independent of each other. As for vowel reduction, unstressed syllables in stressed-timed languages have reduced, shorter vowels than stressed syllables. In other words, stress-timed languages allow vowel reduction in contrast to syllable-timed languages, therefore vowel duration should be more variable in stress-timed languages (Low and Grabe 1995; Low, Grabe and Nolan 2000). Languages are then classified as stressed-timed or syllable-timed depending on the typical phonological properties they exhibit (Dauer 1987). Dauer (1987) advocated a continuous one-dimensional rhythm model in which typical stress- and syllable-timed languages occur at both ends of the continuum, ranging from lowest to highest stressed-based. This model is supported by the fact that there are languages whose properties correspond neither to those of typical stress-timed, nor to those of typical syllable-timed languages. This reflects that rhythm differences in languages are not classes but that these differences are represented in a unified rhythmic continuum or space (Ramus 2002).

CONSONANTAL AND VOCALIC INTERVALS

Consonantal and vocalic intervals (C- and V-intervals respectively) are the basic units for rhythmic measurements in speech streams (Ramus et al. 1999; Grabe and Low 2002) as they are most important for the perception of rhythm. According to Ramus et al. (1999) and Grabe and Low (2002), speech rhythm classes can be acoustically distinguished by monitoring the variability of the

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V- and C-intervals. They used these measurements on the basis that rhythm is reflected in the phonotactic structure of the language. Ramus et al. (1999) hypothesized that (1) higher syllable complexity of stressed-timed languages leads to greater variability in C-interval durations and (2) vowel reduction leads to greater variability in V-interval durations in stressed-timed languages than in syllable-timed ones and ultimately leads to greater complexity in consonantal clustering, causing V-intervals to occupy a smaller percentage of the signal in stressed-timed languages than in syllable-timed languages. In this study, these units are used to measure BK rhythm.

A C-interval is an interval in speech that consists of one or more consonants preceded and followed by a vowel or pause (Ramus et al. 1999). The bi-syllable word *encam* /ɑnʤɑ:m/ [result] in isolation consists of two C-intervals: /nʤ/, which occurs between the initial vowel /ɑ/ and the second /ɑ:/, and the second interval /m/ occurs between the second vowel /ɑ:/ and the last pause. Structurally, C-intervals can be simple, consisting of one consonant (c) segment (e.g., the second interval in *encam*) or they can be complex, consisting of two or more c-segments (e.g., the first interval in *encam*). C-intervals can stretch across syllable boundaries, i.e., the syllable boundary between the /n/ and the /ʤ/ in the first C- interval of *encam* does not separate the interval. In utterances that consist of more than one word, C-intervals also stretch across word or sentence boundaries, as long as these boundaries are not marked by a pause (Dellwo 2010).

C-interval complexity refers to the number of consonant segments in a C-interval (ibid.). Languages allow for a greater variety of complex syllable clusters but they can arrange them in a way that keeps C-interval complexity low. Intervocalic consonantal complexity varies from language to language and stress-timed languages have significantly higher numbers of complex C-clusters than syllable-timed languages (ibid.). This is reflected on the acoustic level by the variability of C-interval durations. Languages that exhibit high levels of consonantal complexity reflect higher variability in C-interval durations.

A V-interval is an interval in speech that consists of one or more vowels preceded and followed by a consonant or pause. The Kurdish word *encam* /ɑnʤɑ:m/ consists of two V-intervals: /ɑ/ preceded by the initial pause and followed by the consonant /n/ and the second interval /ɑ:/ that occurs between the consonants /ʤ/ and /m/. The vowels typically form the syllable nucleus and V-intervals typically consist of one vowel or diphthong only. It is, however, possible that two vowels clash together at word boundaries in multi-word utterances in which one word finishes with a vowel and the following word starts with another vowel. The complexity of the vocalic clusters is mainly shown by whether languages allow vowel reduction, which is a feature of stressed-timed languages (ibid.). Because vowel reductions are characterized in the time domain by shorter durations, languages that require a variety of reduced and non-reduced vocalics should reflect this on an acoustic level by highly variable V-interval durations.

RHYTHM METRICS

Based on the segmentation of a speech signal into consonantal and vocalic intervals, rhythm metrics or rhythmic indexes (Salem and Pillai 2019) can be calculated as a means to study the rhythm class by measuring the variability of segmental intervals in the speech stream (Ramus and Mehler 1999). In this approach, the existence of the traditional stress-timing/ syllable-timing dichotomy is reinterpreted and a set of metrics is proposed to distinguish languages according to their traditional rhythm classifications. The approach focuses on two phonological features proposed by Dauer (1987), namely, syllable structure and vowel reduction, which have direct consequences on the duration of consonantal (C-) and vocalic (V-) intervals. According to Ramus (2002), the speech is segmented into alternating V- and C- intervals which are measured along three durational metrics: %V, ΔC and ΔV. Percent vowel (%V) is the percentage of vocalic content in the speech stream relative to the total segmental content that is measured by totalling the duration of the V-intervals divided by the combined total duration of the V- and C-intervals. Delta C (ΔC) shows the standard deviation of the C-intervals, and Delta V (ΔV) represents the standard deviation of the V-intervals. Stressed-timed languages are characterized by high alternating variability in the duration of V- and C-intervals (high scores for ΔC and ΔV). This is due to the typical lengthening of the consonants and vowels in stressed syllables, relative to the shortening of vowels and consonants in unstressed syllables. Meanwhile, syllable-timed languages show lower alternating variability in segmental interval length (low scores for ΔC and ΔV). This is due to the greater uniformity in syllable structure resulting from less lengthening of vowels and consonants in stressed syllables and less reduction in unstressed syllables. It is concluded that %V and ΔC best represent rhythm

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because these two measures best reflect the accepted classification of the languages under study when plotted together, creating a rhythm space in which rhythmically similar languages are clustered together.

Low and Grabe (1995), Low et al. (2000) and Grabe and Low (2002) suggest different metrics for the study of rhythm, known as pairwise variability indices (PVIs). Raw PVI (rPVI) is the sum of the absolute differences between pairs of successive consonantal or vocalic intervals divided by the number of pairs in the speech sample. This is used to measure consonants because they are less sensitive to changes in tempo. To measure variability in V-intervals, this metric can be normalized (nPVI) by dividing each absolute difference between successive intervals by their mean. Low et al. (2000) state that stress-timed languages exhibit relatively high variability index values for V- and C-intervals, while syllable-timed languages exhibit low variability index values for both intervals. This is different from ΔC and ΔV, which measure the standard deviation of the intervals calculated overall.

Additional metrics that are variations of already-existing metrics but normalized in some way have been developed. Frota and Vigario (2001) suggested the use of standard deviation of normalized percentages of C- and V-intervals. Dellwo and Wagner (2003) suggested Yet Another Rhythm Determination (YARD), which is similar to the PVIs in that z-transformed syllable durations are used for measurement. Furthermore, Dellwo (2006) proposed normalized standard deviation calculations of C- and V-intervals (standard deviation divided by the mean or Varco). Additionally, some studies proposed metrics that rely on the duration of prosodic units rather than segments. For example, Barry et al. (2003) employed a syllable-based PVI calculation, while Nolan and Asu (2009) measured the nSPVI (normalised syllable PVI) and nFPVI (normalised foot PVI) – similar to the normalized PVI of Grab and Low (2002) but measuring the duration of the syllable and foot respectively.

Analysing rhythm using metrics is considered somewhat controversial and unreliable, as results vary according to different factors such as speakers, elicitation methods and the syllable composition of the materials (Arvaniti 2012), but the use of the metrics remains a frequent and prevalent measure of rhythm class in the literature. This method has provided clear evidence for the acoustic reality of rhythm class and serves as a methodological framework for analysing many languages. It supports the idea that "the standard rhythm classes are meaningful categories, that not only appeal to intuitions about rhythm, but also reflect actual properties of the speech signal in different languages" (Ramus et al. 1999, 387). This study adopts this approach for the analysis of the BK rhythm pattern, especially the metrics proposed by Ramus et al. (1999). Ramus et al.'s (1999) metrics have been studied by many linguists over recent decades, demonstrating the efficiency of this approach in analysing the acoustic rhythmic features of languages of the world (Ramus 2002; Lin and Wang 2007; Dellwo 2010; Mairano and Romano 2011; Arvaniti 2012) or dialects of the same language (for dialects of Arabic, see Ghazali et al. 2002; Hamdi et al. 2004).

RESEARCH PROCEDURE AND METHODOLOGY

This study employs an analysis of the rhythm metrics proposed by Ramus et al. (1999): %V (percentage of vocalic content), ΔC (standard deviation in C-interval length) and ΔV (standard deviation in V-interval length). The study is different from Ramus et al. in that 10 speakers, both genders, were chosen as subjects while Ramus et al. had only four female speakers from each language examined. Additionally, this study was based on 10 short individual declarative sentences representing read speech, in addition to spontaneous speech, while Ramus et al. had only five sentences as read speech. Finally, this study focuses on BK, which is not among the languages studied in Ramus et al.

Participants

The speech material was produced by 10 BK native speakers from the University of Zakho: three males and seven females. They were students at the University of Zakho, and their ages ranged between 19 and 22. The speakers were from various Bahdini-speaking areas such as Duhok, Zakho, Akre and Amedi. Their participation was voluntary and they were informed that they had the right to withdraw from the study if they wanted to. Prior to recording, the speakers were asked to provide written consent to be recorded.

In this study, a sufficient number of speakers were recruited to try to identify and overcome any problems that may result from inter-speaker variability and thus obtain, to some extent, robust and reliable metric scores.

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SPEECH MATERIAL

The read experimental sentences were different both in their length and the type of syllables they contained (see Table 1). The BK sentences were written using the Kurmanji Latin writing system; transcriptions are provided in IPA revised version symbols and the syllable structures are given using C (consonant) and V (vowel).

Table 1. Experimental sentences

1.	*çavêt wî kurî kulbun* [the eyes of that boy were hollow]	/ ʧɑːveːt wiː kʉriː kʉlbuːn/ CVː.CVːC.CVː.CV.CVː.CVC.CVːC
2.	*ew zaruke keftin* [the children fell]	/ʔaw zɑːrʉkɑ kɑftɨn/ CVC.CVː.CV.CV.CVC.CVC
3.	*kenîn zaruka dilxoš diket* [laughing makes children happy]	/kɑniːn zɑːrʉkɑː dɨlxoʃ dɨkɑt/ CV.CVːC.CVː.CV.CVː.CVC.CVC.CV.CVC
4.	*cîranêt me hemî rabun* [all our neighbours were up]	/ʤiːrɑːneːt mɑ hamiː rɑːbuːn/ CVː.CVː.CVːC.CV.CV.CVː.CVː.CVːC
5.	*ew dare hamî sotin* [all those trees were burned]	/ʔaw dɑːra hɑmiː sotɨn/ CVC.CVːCV.CV.CVː.CV.CVC
6.	*sotin ya dijware* [the burn hurts]	/sotɨn jɑː dɨʒwɑːrɑ/ CV.CVC.CVː.CVC.CVː.CV
7.	*ew ji tirsa revîn* [they ran away because of fear.]	/ʔaw ʒɨ tɨrsɑː rɑviːn/ CVC.CV.CVC.CVː.CV.CVːC
8.	*ewan warêt xo hêlan* [they left their countries]	/ʔawɑːn wɑːreːt xo heːlɑːn/ CV.CVːC.CVː.CVːC.CV.CVː.CVːC
9.	*jotyara zavî kêlan* [the farmers cultivated their lands]	/ʤotjɑːrɑː zɑviː keːlɑːn/ CVC.CVː.CVː.CV.CVː.CVː.CVːC
10.	*kêlan karekê bi zehmete* [cultivating is hard work]	/keːlɑːn kɑːrɑkeː bɨ zaħmɑtɑ/ CVː.CVːC.CVː.CV.CVː.CV.CVC.CV.CV

The test sentences were presented to the speakers in a randomized order. No context was given and no fillers were used, as the sentences were quite different. Since this study represents the first attempt to analyse rhythm in BK, it is thought that read speech is the most appropriate speech material as it includes less variation and is more controlled with respect to speech rate than other speaking styles.

For the spontaneous speech, the speakers were asked to talk about a topic they were interested in. They were given time to think about their topic and what they wished to say. The speakers were recorded when they felt prepared and ready to talk. Ten utterances from each speaker were extracted thus, the total number of spontaneous utterances was 100 (10 utterances × 10 speakers).

Two types of speech (read and spontaneous) were used in this study to help identify whether the calculations are consistent across speech types or whether speech type has any effect.

DATA COLLECTION PROCEDURES

For the production test, the speakers were individually asked to read the sentences at a normal speech rate and were given time to read through the text before the recordings were made. Their readings were recorded in a soundproof booth, using a MacBook Pro computer, a Creative Headset HS-600 noise-cancelling microphone and the speech analysis software Praat version 6.1.16 (Boersma and Weenink 2020). The data was digitized at 16 kHz. When hesitations or errors occurred during the recordings, the speakers were asked to repeat the utterances at the end of the session. After that, the spontaneous speech was recorded.

PROCEDURES OF DATA ANALYSIS

The data were segmented in Praat. The phonemes of each sentence were marked using both auditory and visual cues in tier one of Praat textgrid. Segments were identified and located as precisely as possible manually, using the phoneme inventory of BK. Then, they were classified as vowels (V) or consonants (C) in tier two. The V- and C-intervals were indicated in tier three. A V-interval was placed between the onset and the offset of a vowel, or of a cluster of vowels; similarly, a C-interval was located between the onset and the offset of a consonant, or of a cluster of consonants. Figure 1 represents the segmentation process of a sentence as produced by a speaker.

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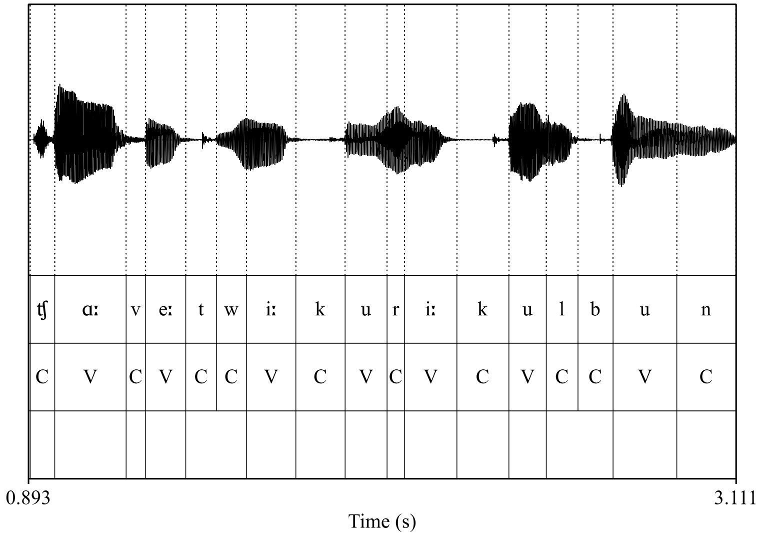
Figure 1. The segmentation process of one of the experimental sentences as produced by one of the speakers in the sample



Thus, the following sentence is comprised of eight consonantal and seven vocalic intervals.

Çavêt *wî* *kurî* *kulbun*.

CVCVC CV CVCV CVCCVC

[The eyes of that boy were hollow.]

For the next step, the following measurements were extracted:

1) the duration of the V- and C-intervals in each sentence;
2) the sum of V- and C-intervals in each sentence which constitutes the total duration of the sentence;
3) %V: the proportion of V-intervals within the sentence, that is, the sum of V-intervals divided by the total duration of the sentence multiplied by 100;
4) ΔV metrics were derived by calculating the standard deviation of the V-interval durations within each sentence;
5) ΔC metrics were derived by calculating the standard deviation of the C-interval durations within each sentence.

The results of the measurements were saved as Excel files and the scores were derived using Excel formulas. The sentences constituted 72 syllables. The total number of segments (both consonants and vowels) analysed was 170 × 10 = 1700. The total number of intervals was 1,484 (764 C-intervals and 720 V-intervals). For the spontaneous speech, the total number of syllables came to 3,460. The total number of segments came to 8,160. The total number of intervals was 7000 (3440 V-intervals and 3,560 C-intervals).

RESEARCH RESULTS

The main measurements of BK read speech are presented in Table 2. The average proportion of V-intervals (%V) and the average standard deviations of consonantal (ΔC) and vocalic (ΔV) intervals across all sentences as produced by all speakers are shown. ΔV and ΔC are shown multiplied by 100 for ease of reading.

Table 2. the number of V- and C-intervals and the values of %V, ΔV and ΔC for BK

V-intervals	C-intervals	%V	ΔV	ΔC
720	760	49.35	3.84	4.73

The %V score (49.35) indicates that the overall proportion of time during which speech is vocalic is high. This suggests that BK is less likely to allow vowel reduction. The score (3.84) for ΔV is low, which indicates that there is limited variability in the vowel duration between stressed and unstressed syllables, i.e., there is not much lengthening of vowels in stressed syllables or reduction in unstressed syllables. Additionally, the ΔC measurement (4.73) indicates that the proportional amount of time spent on C-intervals is low, which indicates that there is less variability in the C-intervals' length, i.e., BK syllable structure is not so complex. Thus, BK scored low on ΔC and ΔV due to the greater uniformity in syllable structure, with limited lengthening of vowels and consonants in stressed syllables and limited reduction length in unstressed syllables.

PHONOTACTIC COMPLEXITY

It is also important to study whether BK language material is generally representative of stress-timing or syllable-timing with regard to the syllabic complexity rationale. The study found that the BK syllable structure is not particularly complex and there is low complexity and variability in the length of C-intervals. Thus, the syllable complexity and number of consonants that BK admits intervocalically in read and spontaneous speech were analysed.

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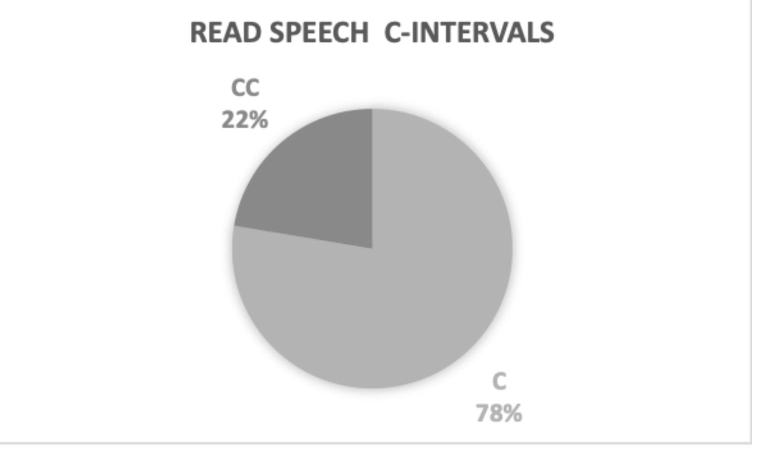
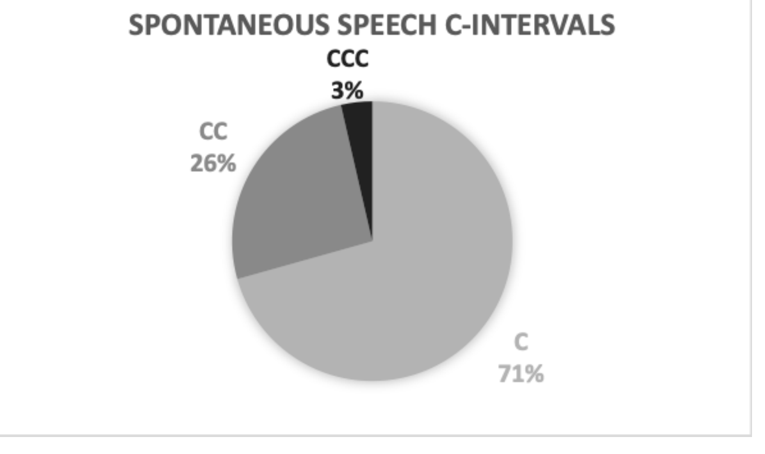
The read speech consisted of 10 utterances constituting 72 syllables. The syllable structures identified were CV and CVC. The CV structure was dominant, occurring in 46 syllables (64%), compared to 26 CVC syllables (36%). In spontaneous speech, 3,460 syllables were analysed and more complex syllables were identified due to vowel deletion. The structures identified were CV, CVC, CCV, CCVC, CVCC, CCCV and CCCVC. CV was the dominant structure, occurring in 2,330 syllables (67%), followed by 880 CVC structures (25%). At the other end of the scale, CCV and CCVC were only used in 3% of syllables each and the rarest structures were CCCV (0.5%) and CCCVC (0.25%). Thus, in both types of speech CV and CVC were the most dominant syllable structures.

Figure 2. C-interval complexity in BK read and spontaneous speech





As for the C-interval complexity in both read and spontaneous speech, the number of c-segments in the C-intervals was examined and the frequency of each type of C-interval was established. The results are summarized in Figure 2.

In the read speech, out of the 764 C-intervals, 594 C-intervals (78%) had one c-segment, while only 170 (22%) had two c-segments. More complex C-intervals consisting of triple consonant clusters were not found. Meanwhile in spontaneous speech, the total number of C-intervals was 3,560; of these, 2,550 (71%) had one c-segment, 930 (26%) had two c-segments, and only 130 (3%) had three c-segments. Thus, the more prominent cluster type consists of one consonant only, while the least prominent consists of three.

SPEAKING STYLE AND INTER-SPEAKER VARIABILITY IN BK RHYTHM

Variability in rhythm metrics was studied as a function of speaker and speaking style to identify whether the scores were consistent across these factors. The results are shown in Table 3.

Table 3. rhythm variability across speakers and speaking styles (ΔV and ΔC values multiplied by 100 for ease of reading)

	Read speech			**Spontaneous speech**		
S	**%V**	**ΔV**	**ΔC**	**%V**	**ΔV**	**ΔC**
1	47.55	3.6	3.72	48.08	3.28	5.52
2	50.46	3.97	6.25	41.97	3.91	7.09
3	49.01	2.99	3.82	44.34	2.13	4.89
4	52.04	4.74	4.08	48.13	3.38	4.34
5	51.72	2.93	4.03	48.85	3.51	4.40
6	52.04	2.92	3.55	46.26	3.59	5.19
7	50.03	4.72	5.3	46.43	3.84	5.41
8	44.56	3.14	4.95	47.58	3.05	4.59
9	51.14	5.85	7.04	45.18	2.53	4.66
10	44.99	3.58	4.54	44.31	4.23	8.17
Mean	49.35	3.84	4.73	46.11	3.34	5.43
Variance	7.81	0.96	1.35	4.68	0.40	1.57
SD	2.79	0.98	1.16	2.16	0.63	1.25

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The table shows the mean score for the three metrics –%V, ΔV and ΔC – for each speaker's read and spontaneous speech. The speakers seem to display lower average %V and higher average ΔC for spontaneous speech compared to the read passage values, indicating more syllable-timing features in the spontaneous speech.

Regarding variance across the speakers for read speech, the scores show great speaker variability for %V (7.81) due to the high value of the variance, and less speaker variability for ΔV (0.96) and ΔC (1.35) due to the low values of the variance. In the spontaneous speech, there was high variability for %V (4.68), although this was less than the variability of %V in read speech. Meanwhile, there was less speaker variability for ΔV (0.40) and ΔC (1.57).

To examine the effect of speaking style on the measurements of the durational metrics, a one-way ANOVA was used. The results show that speaking style had a statistically significant effect on %V, as $F(1,18) = 8.40858$; $p = 0.00955$. However, speaking style did not have a significant effect on ΔV ($F(1,18) = 0$; $p = 1$) or ΔC ($F(1,18) = 1.66236$; $p = 0.213608$).

DISCUSSION

This study attempts to identify the rhythmic class of BK. The BK read speech results were compared with those of the languages examined by Ramus et al. (1999) in Table 4, which ranks the languages from most to least stress-timed.

Table 4. %V and ΔC scores of BK ranked with the languages examined by Ramus et al. (1999)

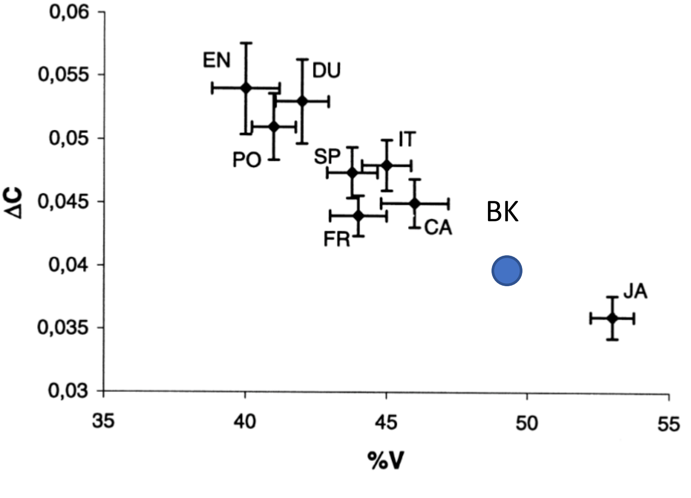
Language	**%V**	**ΔC**
English	40.1	5.35
Polish	41.0	5.14
Dutch	42.3	5.33
French	43.6	4.39
Spanish	43.8	4.74
Italian	45.2	4.81
Catalan	45.6	4.52
BK	49.4	4.73
Japanese	53.1	3.56

The table shows that BK has a higher %V score than the languages classified as stress-timed (English, Polish and Dutch) and syllable-timed (French, Spanish, Italian and Catalan), second only to Japanese. In terms of ΔC, the score definitely places BK among the syllable-timed languages, as it lies between the syllable-timed languages Spanish (4.74) and Italian (4.81). Thus, based on its values for %V and ΔC, BK is consistent with syllable-timed languages.

The location of BK in the three-dimensional space proposed by Ramus et al. (1999) for the languages they studied is given in Figure 3.

According to these parameters, BK can be classified a syllable-timed language, along with Spanish, Italian, French and Catalan. Thus, the hypothesis that BK is a syllable-timed language is supported, as there is low alternating variability in the both vocalic and consonantal segmental intervals.

Figure 3. The distribution of BK alongside the languages studied by Ramus et al (1999) over the %V and ΔC planes.



The classification of BK as a syllable-timed language is supported by the relatively low complexity of its syllable structure and low number of complex C-clusters. In syllable-timed languages, syllables are more similar in duration because they are of the same type (Nespor et al. 2011). For example, in Spanish and French, more than half of syllables (by type frequency) consist of a consonant followed by a vowel (CV) (Dauer, 1983). In Italian, 60 percent of syllable types are CV (Bortolini 1976). This is similar to BK, in which the majority of syllables were CV in both read (63%)

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and spontaneous speech (65%). For this reason, the majority of the C-intervals have one c-segment in BK in both read (78%) and spontaneous speech (71%). The C-interval with a c-segment is most pronounced in syllable-timed languages such as French and Italian and is less pronounced in stressed-timed languages such as English and German (Dellwo 2010). Most syllables in syllable-timed languages are open syllables, which is another phonological property of this group: that open syllables are more prevalent than in stress-timed languages (Schmid 2004 cited in Mairano 2011).

Furthermore, it was found that BK speakers exhibit syllable-timing features in both read and spontaneous speech. However, the value of %V was lower and that of ΔC higher in the spontaneous utterances than in the read speech, suggesting that speakers exhibit greater temporal variation in spontaneous utterances, and therefore syllable-timing characteristics are more strongly manifested in spontaneous speech. Furthermore, the analysis of the data shows that the rhythm measures, particularly %V, are influenced by the speaker and speaking style. It turns out that %V depends heavily on the speakers and speaking style. There is high speaker variability for %V in both read and spontaneous speech, but variability was greater in read speech than in spontaneous speech. This is related to the variability in speaking rate in read speech, although speakers were told to read at a normal speaking rate, while when speaking spontaneously, speakers produced the utterances naturally and therefore there was less variation in their vocalic durations. Meanwhile, lower speaker variability was observed for both ΔV and ΔC values in both speaking styles. Likewise, %V was also significantly influenced by speaking style, with a lower value for spontaneous speech than for read speech. This may be related to the different segmental content of speech samples and vowel elisions in spontaneous speech (Salem and Pillai 2019). ΔV and ΔC, on the other hand, were not significantly influenced by the speaking style.

CONCLUSION

The study represents the first attempt to acoustically analyse the rhythm pattern of BK and establish where it stands in the rhythmic classification of world languages. It is classified as a syllable-timed language according to the measurements presented by Ramus et al. (1999). It is placed in this group because it has a high vowel content and a low consonant variance. This suggests that BK has fewer syllable types and does not allow vowel reduction. The study also analysed the effects of speakers and speaking styles on rhythm measures and found that only %V was influenced by these variables.

This study was limited to one subdialect of Kurdish, namely BK. Therefore, it is recommended that similar studies be carried out on other dialects and sub-dialects of Kurdish to find out whether they all cluster around syllable-timed languages or whether there are dialectal variations in rhythm patterns.

The study makes a valuable contribution to the understanding of BK phonetics and phonology by conducting a preliminary experimental study on the rhythm class of one of the sub-dialects of Kurdish, demonstrating its clear durational metrics.

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REFERENCES

1. Abercrombie, D. (1967). *Elements of General Phonetics*. Chicago: Aldine.

2. Arvaniti, A. (2012). "The Usefulness of Metrics in the Quantification of Speech Rhythm." *Journal of Phonetics* 40 (3), 351–373. https://doi.org/10.1016/j.wocn.2012.02.003

3. Barry, W., Andreeva, B., Russo, M., Dimitrova, S. and Kostadinova, T. (2003). "Do Rhythm Measures Tell Us Anything about Language Type?" In: *Proceedings of the Fifteenth International Congress of Phonetic Sciences: ICPhS*. Barcelona, 2693–2696.

4. Boersma, P. and Weenink, D. (2020). Praat: Doing Phonetics by Computer (version 6.1.16) [Computer program]. Available at: <https://www.fon.hum.uva.nl/praat/> (accessed October 2024).

5. Bortolini, U. (1976). "Tipologia sillabica dell'Italiano: Studio statistic." In: Simone, R., Vignuzzi, U., Ruggiero, G. (eds.) *Studi di fonetica e fonologia* 1. Roma: Bulzoni, 5–22.

6. Dauer, R. M. (1983). “Stress-timing and Syllable-timing Reanalyzed.” *Journal of Phonetics* 11, 51–62.

7. Dauer, R. M. (1987). “Phonetic and Phonological Components of Language Rhythm.” In: *Proceedings of the Eleventh International Congress of Phonetic Sciences.* Tallinn: Academy of Sciences of the Estonian S.S.R, 447–450.

8. Dellwo, V. (2006). “Rhythm and Speech Rate: A Variation Coefficient for DeltaC.” In: Karnowski, P. and Szigeti, I. (eds.) *Language and Language-Processing: Proceedings of the Thirty-Eighth Linguistics Colloquium*, *Piliscsaba 2003*. Frankfurt am Main: Peter Lang, 231–240.

9. Dellwo, V. (2010). *Influences of Speech Rate on the Acoustic Correlates of Speech Rhythm: An Experimental Phonetic Study Based in Acoustic and Perceptual Evidence*. PhD Thesis. University of Bonn.

10. Dellwo, V. and Wagner, P. (2003). “Relations between Language Rhythm and Speech Rate”. In: *Proceedings of the Fifteenth International Congress of Phonetic Sciences: ICPhS.* Barcelona, 471–474.

11. Frota, S. and Vigario, M. (2001). “On the Correlates of Rhythmic Distinctions: The European/ Brazilian Portuguese Case.” *Probus* 13, 247–275.

12. Ghazali, S., Hamdi, R. and Barkat, M. (2002). “Speech Rhythm Variation in Arabic Dialects.” In: *Proceedings of the First International Conference on Speech Prosody*. Aix-en-Provence, 331–334.

13. Grabe, E. and Low, E. L. (2002). “Durational Variability in Speech and the Rhythm Class Hypothesis.” In: Gussenhoven, C. and Warner’s N. (eds.) *Papers in Laboratory Phonology 7*. Berlin: Mouton de Gruyter, 515–546.

14. Hamdi, R., Defradas, M., Ferragne, E. and Pellegrino, F. (2004). “Speech Timing and Rhythmic Structure in Arabic Dialects: A Comparison of Two Approaches.” *International Speech and Communication Association* (October), 1613–1616. Available at: <https:/shs.hal.science/halshs-01740967v1/> (accessed October 2024).

15. Hasan, A. M. (2009). “Consonant Clusters in Kurdish.”-*Journal of Duhok University* 1, 1–8.

16. Hasan, A. M. (2012). *Kurdish Intonation with Reference to English*. Unpublished PhD thesis. University of Ulster.

17. Hasan, A. M. (2016). "The Phonological Word and Stress-shift in Northern Kurmanji Kurdish." *European Scientific Journal*, 12 (26), 371–399. https://doi.org/10.19044/esj.2016.v12n26p370**.**

18. Hasan, A. M. and Mohammed, F. O. (2023). "The Realisation and Phonetic Features of the Glottal Stop in Bahdini Kurdish." *Estudios de Fonética Experimental* 32, 9–20.

19. Khan, M. B. and Salih, S. F. (2017). "Vekolina acostikiya vawelin zimane kurdi (govera behdini) [Kurdish Vowels – Bahdinan Region Acoustic Research]." *Humanities Journal of University of Zakho* 5 (1), 1–9.

20. Kurdish Academy of Language. (2023). *Kurdish Language*. Available at <https://kurdishacademy.org/?p=141> (accessed July 2023).

21. Ladefoged, P. (2006). *A Course in Phonetics*. 5th ed. Boston: Michael Rosenberg.

22. Lin, H. and Wang, Q. (2007). "Mandarin Rhythm: An Acoustic Study." *Journal of Chinese Language and Computing* 17 (3), 127–140.

23. Low, E. L. and Grabe, E. (1995). "Prosodic Patterns in Singapore English." In: *Proceedings of the Intonational Congress of Phonetic Sciences* (*ICPhS*). Vol. 3. Stockholm, 636–639.

24. Low, E. L., Grabe, E. and Nolan, F. (2000). "Quantitative Characterisations of Speech Rhythm: Syllable-timing in Singapore English." *Language and Speech* 43 (4), 377–401.

25. Mairano, P. (2011). *Rhythm Typology: Acoustic and Perceptive Studies.* Universita degli studi di Torino.

26. Mairano, P. and Romano, A. (2011). "Rhythm Metrics for 21 Languages." In: *Proceedings of the Seventeenth International Congress of Phonetic Sciences*. Hong Kong, 1318–1152.

27. Marif, A. H. (1976). *Zimanî kurdî libar roşanî fonetîkda* [Kurdish Language in the Light of Phonetics]. Baghdad: Zanyari Kurdi Press.

28. Nespor, M., Shukla, M. and Mehler, J. (2011). "Stress-Timed *vs*. Syllable-Timed Languages." In: Oostendorp, M. V., Ewen, C. J., Hume, E. and Rice, K. (eds.) *The Blackwell Companion to Phonology*. *Vol. 2 Suprasegmental and Prosodic Phonology*.

John Wiley & Sons, Ltd., 1147–1159. https://doi.org/10.1002/9781444335262.wbctp0048

29. Nolan, F. and Asu, E. L. (2009). "The Pairwise Variability Index and Coexisting Rhythms in Language." *Phonetica* 66, 64–77.

30. Pike, K. L. (1945). *The Intonation of American English*. Ann Arbor: University of Michigan Press.

31. Ramus, F. (2002). "Acoustic Correlates of Linguistic Rhythm: Perspectives." In: *Proceedings of Speech Prosody*. Aix-en-Provence, 115–120.

32. Ramus, F. and Mehler, J. (1999). "Language Identification with Suprasegmental Cues: A Study Based on Speech Re-synthesis." *The Journal of the Acoustical Society of America* 10 (1), 512–521.

33. Ramus, F., Nespor, M. and Mehler, J. (1999). "Correlates of Linguistic Rhythm in the Speech Signal." *Cognition* 73, 265–292.

34. Roach, P. (1982). "On the Distinction between 'Stress-timed' and 'Syllable-timed' Languages." In: Crystal, D. (ed.) *Linguistic Controversies*: *Essays in Linguistic Theory and Practice*. London: Edward Arnold, 73–79.

35. Salem, N. M. and Pillai, S. (2019). "An Acoustic Analysis of the Rhythm of Yemeni Arabic." *Journal of Modern Languages* 29, 1–22. https://doi.org/10.22452/jml.vol29no1.1

36. Shokri, N. (2002). "Syllable Structure and Stress in Bahdinani Kurdish." *Language Typology and Universals* 55, (1), 80–97.

37. Taghva, N. and Zadeh, V. A. (2016). "Comparison of English Language Rhythm and Kalhori Kurdish Language Rhythm." *Advances in Language and Literary Studies* 7 (2), 226–230. http://dx.doi.org/10.7575/aiac.alls.v.7n.2p.226

38. Thackston, W. M. (2006). *Kurmanji Kurdish: A Reference Grammar with Selected Readings.* Available at: <https://zimannas.wordpress.com/wp-content/uploads/2020/04/kurmanji_complete.pdf> (accessed October 2024).