

A Rhythmic Analysis of Scottish Gaelic Using Durational Metrics

by

Jackson Kellogg

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Graduate Supervisory Committee:

Kathryn Pruitt, Chair
Elly van Gelderen
Tyler Peterson

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ABSTRACT

Languages have long been studied through the rhythm class framework, which discriminates them into separate classes on the basis of shared rhythmic properties. Originally these differences were attributed to the isochronous timing of different prosodic units, such as stress intervals in “stress-timed” languages and syllables in “syllable-timed” languages. More recent work has turned to durational metrics as a means of evaluating rhythm class, by measuring the variability and proportion of segmental intervals in the speech stream. Both isochrony and durational metrics are no longer viewed as correlative with natural language rhythm, but durational metrics in particular have remained prevalent in the literature. So long as the conclusions of durational metrics are not overextended, their analysis can provide a useful mechanism for assessing the compatibility of a language with a given rhythm class by way of comparative analysis. This study therefore presents a durational-metric comparison of Scottish Gaelic, a language which has frequently been described as stress-timed but has never been empirically tested for rhythm class, with English, a prototypical and well-studied example of a stress-timed language. The Gaelic metric scores for %V (percentage of vocalic content), ΔV (standard deviation in vocalic interval length), and ΔC (standard deviation in consonantal interval length) (Ramus et al. 1999) are shown to be very similar to those measured for English, indicating that the language displays similar patterns of durational variability and segmental proportion typically ascribed to a rhythmically stress-timed language. This provides clear support for the classification of Scottish Gaelic as stress-timed.

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CHAPTER 1

INTRODUCTION

Since the 1940s, a steady current of phonetic research has revolved around the so-called “rhythm class hypothesis”, which proposes the typological grouping of certain languages based on rhythmic quality. At first these groupings were attributed to the isochrony (or equivalent timing) of different prosodic units – stress intervals in the case of “stress-timed” languages such as English and Dutch, and syllables in the case of “syllable-timed” languages such as Spanish and French. Over time and under mounting counterevidence, however, support for the reality of isochrony in natural language has gradually deteriorated – though due to their tenacious basis in perceptual anecdote, the belief in rhythm classes has not commensurately wavered. In more recent years, research on the subject has turned to durational metrics as a means of studying rhythm class instead, by measuring the variability of segmental intervals in the speech stream. And despite the fact that like isochrony, the usage of durational metrics has also been considered controversial, they have remained a frequent measure of rhythm class and are still prevalent in the literature.

To some degree, durational metrics have been successful in correlating the perceptual impression of rhythm classes with acoustically measurable language groupings. The metrics can therefore implicitly determine rhythm class by way of comparative analysis. To this end, the study of durational metrics can remain viable so long as their conclusions remain conservative and transparent, and they are not overly conflated with the rhythm classes they indicate. One application of durational metrics is the study of languages which have been previously ascribed to a certain rhythm class

without supporting evidence. In such cases, durational metrics can determine whether the language in question displays patterns of durational variability and segmental proportion typical to languages of that rhythm class. This type of analysis can also provide an early prosodic profiling of the language, especially considering that durational metrics are so easy to calculate.

Scottish Gaelic is a language which has been labeled as stress-timed. Although it has never been rhythmically studied through durational metrics, all the prosodic, phonological, typological, and areal features of Gaelic are indicative of a stress-timed rhythmic character. A durational-metric analysis of the language would therefore not only lend legitimacy to the previously untested classifications of Gaelic as stress-timed, but would also provide further opportunity to explore the connection between durational metrics and perceived rhythm. This thesis therefore presents a durational-metric analysis of Scottish Gaelic, to examine whether the language displays patterns of durational variability and segmental proportion typical to languages such as English which have commonly been described as stress-timed.

CHAPTER 2

RHYTHM CLASSES

2.1 Origins of hypothesis

One of the earliest recorded stirrings of the rhythm class hypothesis dates back to 1940, when the Welsh phonetician Arthur Lloyd James took notice of an impressionistic difference in rhythmic quality between English and French. The first of these languages he described as resembling Morse code, with a high alternating variability of long and short syllables, and the latter a machine gun, with each syllable being roughly the same length. Pike (1945) later observed a similar qualitative difference between the rhythm of English, which he described as belonging to a “stress-timed” rhythm class, and Spanish, which he described as “syllable-timed”. Later, a third rhythm class, “mora-timed”, would be added for Japanese (Abercrombie 1967). These categories were inspired by the idea, common at the time, that language rhythm is determined by isochrony, or the equal duration of certain prosodic units. Rhythmic differences between languages were attributed to the difference in units isochronized, with each stress interval (the time between two primary stresses) being equally long in English and each syllable being equally long in Spanish and French, to create the impression of a language-specific periodic “beat”. Since the original conception of stress- and syllable-timing, the history of the rhythm class debate has proceeded in three broad stages – early approaches to rhythm classification from the 1940s to 1999, mainly based around the search for isochrony, the introduction of durational metrics as a means of studying rhythm from 1999 to 2009, and the subsequent reevaluation of durational metrics and the rhythm class hypothesis from 2009 onwards. Each of these stages will be discussed in detail here,

followed by a justification of why there is still merit in studying languages through the rhythm class framework.

2.2 Rhythm class history

2.2.1 Early approaches to rhythm (1940-1999)

P. M. Bertinetto (1989) provides an excellent literature review of the study of rhythm classes between 1939 and 1989, outlining the various schools of thought which have tackled the debate. Among these were the researchers who considered rhythmic isochrony in language to be an acoustic reality, and either hedged about their results when failing to find evidence for it or else assumed its existence as a precursor for their research (Bertinetto 1977, Lehiste 1977, Cutler 1980 Faure & Rossi 1980, Nakatani 1981). The lack of proof for the reality of isochrony, however, is somewhat striking – as Bertinetto (1980) says, “Perhaps no other phenomenon of phonology is so widely accepted, with so little supporting evidence” (pg. 100). Those who were willing to question the reality of isochrony form what he calls the “skeptical” movement (Balasubramanian 1980, Crompton 1980, Manrique & Signorini 1983, Roach 1982, Beckman 1982, Scott et al. 1985), and their studies were typically characterized by empirical work in languages other than English which failed to demonstrate prosodic isochrony, followed by the postulation that isochrony may not really exist in natural language at all. Others suggested that even if isochrony may not physically exist at the acoustic level, natural language may still convey the perceptual illusion of isochrony (Classe 1939, Bolinger 1965, Martin 1975, Allen 1975, Roach 1982). One series of studies by Lehiste (1973, 1979) demonstrated that the same temporal structure can be

perceived as isochronous when filtered through speech, and non-isochronous when filtered through non-speech, so that speech itself is what triggers the perception of isochrony.

Beyond doubting the reality of isochrony in language, a number of studies further questioned the stress-timed/syllable-timed dichotomy as an accurate representation of language rhythm. Some proposed new binaries of rhythm class, among them “duration-controlling” vs “duration-compensating” languages (Hoequist 1983a, 1983b), “trailer-timed” vs “leader-timed” languages (Wenk & Wioland 1982), and “striving” vs “switching” languages (Eek & Help 1987), though none were widely adopted in the larger field. Other researchers who questioned the stress-timed/syllable-timed dichotomy turned away from phonetic/acoustic alternatives and looked to phonology instead, considering language rhythm to be a byproduct of the presence or absence of certain phonological tendencies. For stress-timed languages, as converse to syllable-timed, this would entail the reduction of unstressed syllables, the abundance of complex syllable structures, and the gathering of phonological content onto stressed syllables (Bertinetto 1977, 1981, Dasher & Bolinger 1982, Dauer 1983, 1987, Brakel 1985, Hurch 1988). Still more began to examine rhythm classes through listener intuitions (Miller 1984), durational aspects of poetry, syllable reduction in rapid speech, and word length (Faure & Rossi 1968, Fletcher 1987, Port et al. 1987), and the interaction of compensatory shortening and intersyllabic coarticulation (Fowler 1977, 1981, 1983, Manuel & Krakow 1984, Magen 1984, Vayra et al. 1984, Recasens 1987). And although a number of these studies were promising, none of them consolidated enough consensus in the literature to satisfactorily “solve” the rhythm class debate.

The decade after Bertinetto's literature review in 1989 was mostly comprised of similar rhythmic analyses and approaches, often based implicitly around the question of isochrony, with few of them establishing any radical new avenues in the field (Nespor 1990, Font & Mester 1991, Kelm 1991, Beckman 1992, Couper-Kuhlen 1993, Grønnum 1993, Arvaniti 1994, Cauldwell 1996, Dimitrova 1997, O'Dell & Nieminen 1998). It was not until 1999 that a significant new chapter in the history of rhythm classes was initiated with the usage of durational metrics as a means of categorizing rhythm typology.

2.2.2 Durational metrics (1999-2009)

In 1996 Mehler et al. proposed the TIGRE model (Time and Intensity Grid Representation), an innate language discrimination faculty which categorizes speech on the basis of vocalic quality and duration. Their hypothesis was founded on three previous lines of work – the first was the discovery that individuals segment speech on the basis of different prosodic units, namely the foot, the syllable, and the mora, depending on the rhythm class of their native language (Mehler et al. 1981, Cutler et al. 1986, Otake et al. 1993). The second was the finding that infants can discriminate between two languages of different rhythm class, and that by two months of age they can discriminate between any two languages regardless of rhythm class, but only when one is their native language (Bahrick & Pickens 1988, Mehler et al. 1988, Moon et al. 1993, Bosch & Sebastian Galles 1997, Nazzi et al. 1998). Finally the third impetus for the TIGRE model was the demonstrated salience of vowels in infant perception, as opposed to consonants which are essentially interpreted as unanalyzed noise at that stage (Bertoncini et al. 1988, Mehler et al. 1988, Bijeljac-Babic et al. 1993). The speculation was therefore made that by attuning

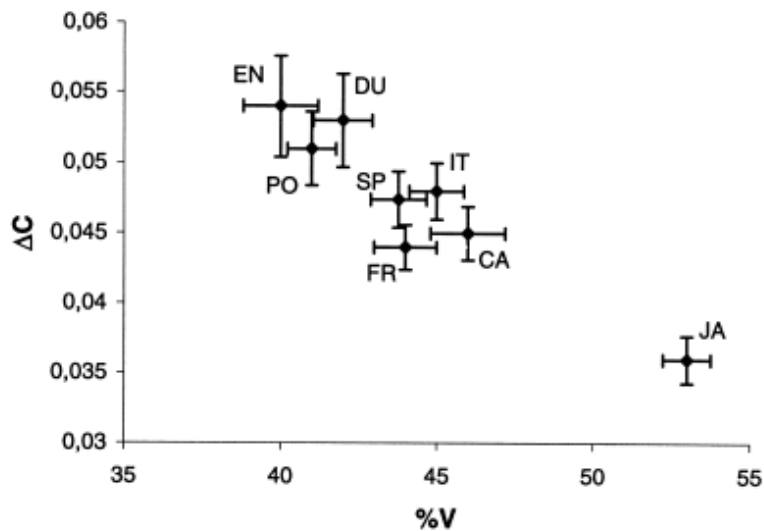
to vowel content, infants must be converging on the basic suprasegmental processing unit of their native language in order to facilitate language discrimination.

Shortly thereafter in 1999, Ramus et al. conducted a landmark study in the history of rhythm classes in which they adapted the TIGRE model into a mapping of durational metrics. They viewed the infant language discrimination studies of the previous decade as compelling evidence for the reality of stress- and syllable-timed rhythm classes, and reasoned that infants can only be interpreting speech as a stream of vowels and consonants. Their experiment involved the segmentation of speech into alternating vocalic and consonantal intervals, which were then measured along three durational metrics. The first of these, %V (Percent Vowel), represents the percentage of vocalic content in the speech stream relative to the total segmental content. This score is derived by totaling the duration of vocalic intervals, which is then divided by the combined duration of vocalic and consonantal intervals overall. The second two metrics, ΔC (DeltaC) and ΔV (DeltaV), represent the standard deviation in the length of consonantal and vocalic intervals respectively. These scores are derived by finding the duration of each interval and then calculating the standard deviation from the average of those durations. A language with a high alternating variability in the length of consonantal and vocalic intervals, with some being comparatively short and others long, will score highly on ΔC and ΔV due to the wider durational range in which the intervals fall. Ramus et al. expected this of stress-timed languages because of their typical lengthening of consonants and vowels in stressed syllables, relative to the shorter duration of vowels and consonants in unstressed, reduced syllables. A language with a lower alternating variability in segmental interval length, on the other hand, will score lower on ΔC and ΔV . This was

expected of syllable-timed languages due to their greater uniformity in syllable structure, with less lengthening of vowels and consonants in stressed syllables, and less reduction in unstressed syllables.

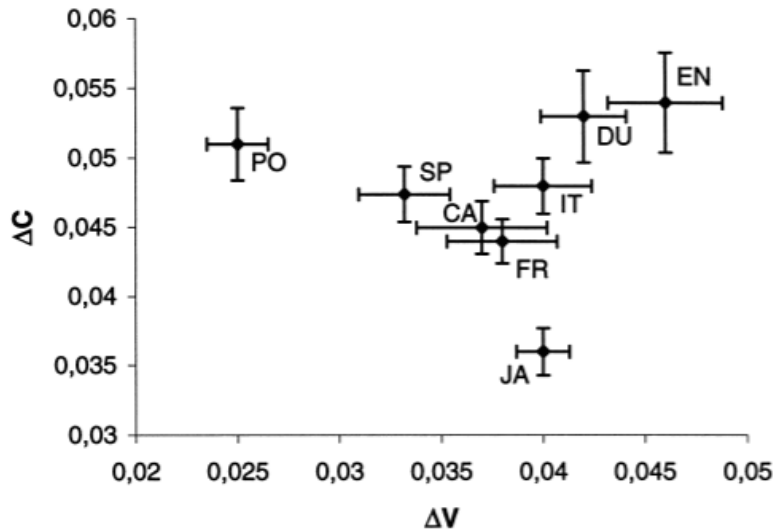
Eight languages which have traditionally been ascribed to different rhythm classes were chosen for the analysis in Ramus et al., the results of which are shown in the figure in (2.1), which shows the mapping of ΔC and %V. The results clearly demonstrated a correlation with rhythm class, with the stress-timed languages English, Dutch and Polish grouping together, and the syllable-timed languages Spanish, Italian, French and Catalan doing the same, while the mora-timed language Japanese was isolated from the rest.

(2.1) %V- ΔC TIGRE grid (Ramus et al. 1999, pg. 273)



Ramus et al. further suggested that Polish may actually belong to a different rhythm class altogether than English and Dutch, as it breaks away from the other stress-timed languages when measured for ΔV , as shown in the figure in (2.2). The other rhythmic groupings, however, remain relatively the same, indicating a degree of consistency between the graphs.

(2.2) ΔV - ΔC TIGRE grid (Ramus et al. 1999, pg. 274)



The results of this experiment were exciting, as rarely had the empirical research of the past half century demonstrated such clear evidence for the acoustic reality of rhythm classes. Consequently, research into durational metrics experienced a massive surge in the rhythm class field, with the original study by Ramus et al. and %V and ΔC in particular serving as the methodological framework for the analysis of many other languages.

Since the introduction of %V and ΔC , a number of alternative durational-metric approaches to the study of rhythm have been put forward (Barry et al. 2003, Wagner & Dellwo 2004, Bertinetto & Bertini 2008, Brown & Weishaar 2010), with the most significant of these being pairwise variability indices or PVIs (Low et al. 2000, Grabe & Low 2002) and variation coefficients or Varcos (Dellwo 2006). PVI measurements, split further into rPVIs (raw pairwise variability indices) and nPVIs (normalized pairwise variability indices), analyze the comparative variation in the length of successive vocalic and consonantal intervals, in contrast with ΔC and ΔV which calculate the standard

deviation of the intervals measured overall. Varco measurements on the other hand, inspired from the observation that ΔC and ΔV can be significantly affected by speech rate (Barry et al. 2003, Dellwo & Wagner 2003), search for a less conditional score through dividing the standard deviation of consonantal intervals by the average duration of consonantal intervals. PVIs and Varcos have appeared frequently in the literature alongside %V and ΔC , with an analysis of all three being a common approach to the durational-metric study of a given language.

2.2.3 Reevaluation of durational metrics (2009-present)

The enthusiasm for durational metrics as a measure of rhythm class continued for around a decade after their inception, with various analyses being published on a typologically diverse spread of languages (among many, Gut et al. 2001, Jian 2004, Asu & Nolan 2005, Lee & Kim 2005, Jeon 2006, Baltazani 2007, Dancovicova & Dellwo 2007, White & Mattys 2007, Russo & Barry 2008, Mok 2009). In 2009, however, a new phase began in the rhythm class epoch with the publication of several articles and experiments reassessing the rhythm class hypothesis and the prior methodology behind durational metrics (Barry et al. 2009, Kohler 2009a, 2009b, Wiget et al. 2010, Horton & Arvaniti 2013). This new wave of scholarship raised significant doubts about durational metrics as an accurate measure of rhythm class, and was initially spearheaded by Amalia Arvaniti, who published three significant articles on the subject from 2009 to 2012.

In her first article, Arvaniti (2009) explores many of the issues inherent in the usage of durational metrics. At the time of her publication only Grabe & Low (2002) had analyzed a large sampling of languages through durational metrics, and as Arvaniti

reviews, their results had indicated that many of the less rhythmically prototypical languages were deemed impossible to classify (reminiscent of the “skeptic” movement of the 1980s which failed to replicate rhythm class findings outside of English).

Furthermore, Arvaniti argues that the differences in durational-metric scores between languages are often not statistically significant or meaningful when mapped on a scatterplot regression line. She highlights the salient point that segmental length can fluctuate for non-rhythmic reasons, such as consonant gemination and vowel length contrast, stress-related lengthening, and position within the prosodic phrase (Klatt 1976, Turk & Shattuck-Hufnagel 2000, Tserdanelis 2005). Arvaniti concludes that views of rhythm class should move away from durational metrics and towards an understanding of intonational prominence and grouping instead, as these are the factors which she believes more objectively correlate with natural language rhythm.

The second of Arvaniti’s articles (2012) delves upon the observed sensitivity of durational metrics to register and style. Reports of languages “shifting” rhythm class under various circumstances have been scattered throughout the literature (Allen & Hawkins 1980, Major 1985, Thomas & Carter 2006, Arvaniti 2009), including the case of dialects or speech rates which significantly alter durational variability, the basis for rhythm metrics (Barry et al. 2003, Dellwo & Wagner 2003, Krivokapić 2013, Turk & Shattuck-Hufnagel 2013, Clopper & Smiljanic 2015). Arvaniti synthesizes a number of these lines of research in her 2012 study, for which she collected and analyzed speech from two stress-timed and two syllable-timed languages in three different registers – sentence reading, story reading, and spontaneous speech – all of which had been used in previous durational-metric analyses. In addition, for each language she recorded multiple

sentences which were constructed to favor more stress-timed, syllable-timed, or “uncontrolled” pronunciations, as she had done previously in 2009. Her results displayed clear variation in metric score depending on register and sentence type, lending credence to the claim that durational metrics are empirically fickle under elicitation.

The third of Arvaniti’s articles (2012, with Ross) addresses the core rationale for the rhythm class hypothesis – that certain languages are perceived as rhythmically different (Lloyd James 1940, Pike 1945). The authors first point out that despite the centrality of the perceptual basis in the rhythm class hypothesis, very few studies have ever tested perceptual intuitions of rhythm class. Arvaniti & Ross argue that those studies which have been conducted (Miller 1984, Scott et al. 1985, Ramus & Mehler 1999, Ramus et al. 2003) do not provide especially conclusive evidence for rhythm classes. For their study, Arvaniti & Ross conducted two experiments whereby participants were played English, German, Greek and Korean sentences low pass-filtered at 450 Hz, and then were told to quantify their similarity to a normalized trochaic beat. The purpose of the experiment was to simultaneously test not only whether participants could distinguish languages on a rhythmic basis, but also whether they could rank them as belonging to one rhythm class or another. The results of both experiments proved that it was difficult-to-impossible for the participants to categorize languages into traditional rhythmic groupings, with similar conclusions being reached in both the adult studies, and significantly in the infant perception studies as well, conducted since then (Rathcke & Smith 2015, White et al. 2016, Chong et al. 2018).

Since Arvaniti’s seminal works questioning the merits of durational metrics, research in the rhythm class framework has mainly followed along two academic paths –

the continued pursuit of durational metrics as a means of analyzing rhythm, often accompanied by a justification of why such work is still valid (among many, Mairano & Romano 2011, Nespor et al. 2011, Beňuš & Šimko 2012, Dorn et al. 2012, Ding et al. 2013, Meftah et al. 2013, Meisenburg 2013, Yang & Chu 2016, German 2018, Reed 2020), or the proposal of some novel approach to rhythm less reliant upon durational metrics (Bertinetto & Bertini 2010, Schiering et al. 2012, Arvaniti & Rodriguez 2013, Tilsen & Arvaniti 2013, Fuchs 2014, Nolan & Jeon 2014, Rathcke 2015, Boll-Avetisyan et al. 2017).

2.3 Present merit of durational metrics

Considering the doubts about durational metrics then, and in the spirit of the previously enumerated studies which have employed their analysis in recent years, I will now present a defense of why durational metrics are still pertinent in modern phonetics. In the first place, languages are frequently labeled as stress- or syllable-timed solely on the basis of perceptual intuition, and with little empirical justification. To identify all such cases would be something of a challenge, with Scottish Gaelic being the relevant example here, but the underlying point is that languages are often attributed to a rhythm class for what are considered fully evident reasons, so that even if a study had been conducted it wouldn't necessarily be cited. This isn't necessarily problematic considering that rhythm classes have always been discussed in the context of perceptual intuition, but in such cases it may still be beneficial for the sake of retrospective ethos to conduct durational-metric analyses and confirm the prior classifications. The labels of stress- and syllable-timed have also been propagated so widely that they have essentially

become self-referential – analyzing a language through durational metrics and then classifying it as stress-timed would not be strictly “incorrect” on an observed basis, as durational metrics have intrinsically come to say something about themselves.

But what is it, exactly, that durational metrics say? Opinions have been widespread, as discussed here, but the general frustration seems to be that durational metrics do not say what they claim to say – that they are not actually correlative measures of natural language rhythm. However, researchers who have decided this have not necessarily taken issue with the metrics themselves, but rather with the overextension of their conclusions. At their face value, durational metrics are not inherently meaningless – %V, ΔC , PVI and Varcos are still measurements of durational variability, of segmental proportion, and of length and timing patterns. It is only when the suggestion is made that they additionally say something about rhythm that controversy arises. And given that such a large database of languages has been studied through durational metrics, there is certainly value in studying more languages through the same framework, if only for the sake of comparative analysis. If a durational-metric study of Scottish Gaelic were to find that its scores were similar to English, perhaps we could not confidently state that Scottish Gaelic and English are both demonstrably members of the stress-timed rhythm class, but at the very least we could still conclude that Scottish Gaelic and English display similar patterns of durational variability and segmental proportion which have been traditionally ascribed to so-called “stressed-timed” languages. Predictions could therefore be made based on the prosodic and phonological properties of the two languages, and could then be falsified or confirmed – the research in and of itself would not be entirely arbitrary.

Furthermore, it is quite possible that despite the refuting of the initial claims about durational metrics, their analysis can still tell us something about a language's prosodic or even rhythmic profile. In Arvaniti's 2012 study, for instance, despite the fact that the metric scores vary depending on register, speaker, and sentence type, and often do not differ at the level of statistical significance, it could be argued that they also stay within a comparatively modest range for any given language – in other words, they are not totally random but rather fall within the confines of the durational-segmental profile of the language in question. If durational metrics then can tell us something about the prosody of a language by way of its timing and duration patterns, then they can also be considered an early prosodic sketch of that language. This is appealing considering how easy the metrics are to calculate, which in fact was one of the reasons for their early success. If the attractiveness of metrics continues to inspire their study, then all that is really required is full transparency and acknowledgment that their original claims are now considered controversial. Beyond that, there is no obvious theoretical or methodological reason why the study of durational metrics should be avoided, so long as the researcher's presumptions and conclusions remain situated within the confined parameters the metrics allow.

2.4 Conclusion

The rhythm class hypothesis has undergone many changes and reinterpretations since its original inception eighty years ago, with perhaps the most unifying characteristic across the various movements being the belief in fundamentally misguided or

unsubstantiated theoretical presumptions. For most of the twentieth century this was evident in the fruitless search for isochrony in natural language, and later on by the conviction in durational metrics as an accurate measure of rhythm class. And although both of these hypotheses have been seriously challenged, the rhythm class hypothesis still persists, not only because durational metrics continue to be popular in phonetic analysis but also because of the perceptual salience of rhythm class, and the many questions and uncertainties which still remain about natural language rhythm. Moving forward in the rhythm class debate, there remains ample opportunity for new theories and hypotheses to be put forward, as well as for the continued relevance of durational metrics so long as they are only considered as incidental correlates of rhythm class, and not as direct measures of rhythm class themselves.

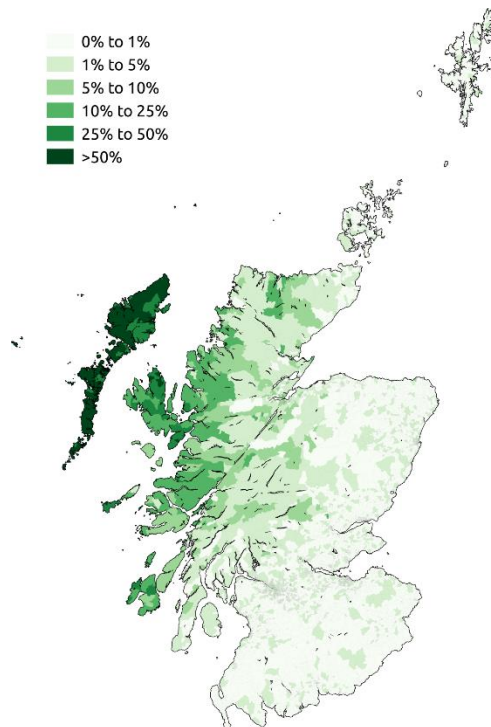
CHAPTER 3

SCOTTISH GAELIC

3.1 Background

Scottish Gaelic, sometimes referred to simply as Gaelic (English pronunciation /gæɪɪk/, as opposed to Irish Gaelic /geɪɪk/, Ladefoged et al. 1998), is a Celtic language spoken primarily in northwestern Scotland. In the Outer Hebrides, Scottish Gaelic is still the primary language of a majority of speakers and remains operative in everyday life, although the long-term survival of the language is seriously endangered (Campsie 2015). Within the Celtic family, Scottish Gaelic forms a part of the Goidelic language group along with Irish and Manx, as distinguishable from the Brythonic languages Welsh, Breton, and Cornish (Ball & Muller 2009). A 2011 census map of Gaelic speakers in Scotland is shown in the figure in (3.1).

(3.1) 2011 Scottish Gaelic Census Map (Nance & Ó Maolalaigh 2019, pg. 2)



Scottish Gaelic is a highly multidialectal language, owing in part to the historical Goidelic continuum from Irish to Gaelic along the geographical spread of the two languages, Scotland originally having been settled by Irish immigrants and Scottish Gaelic deriving from Old Irish (Gillies 2009, Lamb 2001, Ó Baoill 2010). Due to the high concentration of dialectal diversity within the relatively limited extant range of Scottish Gaelic, the exact dialect boundaries of the language are still somewhat unclear – and this despite an abundance of research on the subject (Robertson 1906, Borgstrøm 1940, Ó Dochartaigh 1997, Adger & Ramchand 2006, Bosch 2006, Watson 2010) and the fact that native speakers are highly sensitive to variation and can often identify each other with remarkable specificity. A number of researchers have agreed that there is at least a general divide between the “central” dialect spoken in the Hebrides and the “peripheral” dialect spoken on the circumjacent islands and the Scottish mainland (Jackson 1968, Gillies 2009, Lamb 2001). Of these groupings the central dialect is usually seen as more robust, exhibiting many emergent phonological phenomena such as preaspiration and vocalic epenthesis, whereas the peripheral dialect is less innovative, more consistently retains archaic forms, and is spoken by considerably fewer individuals.

3.2. Phonology

Although there is a fair degree of phonological and prosodic uniformity across the various dialects of Scottish Gaelic, there are also a number of significant differences. For this reason, all of my descriptive generalizations and phoneme inventory charts will assume an analysis of the central dialect of Scottish Gaelic unless otherwise specified.

Of the Gaelic speakers used for the durational metric analysis in Chapter 4, all were raised in the central dialect area.

3.2.1 Vowels

Scottish Gaelic has a nine-way vowel contrast, with unrounded front and central vowels, and rounded and unrounded back vowels. Additionally all vowels contrast in length and all but the high-mid vowels also contrast in nasalization, for a set of twenty-nine contrastive vowels in total, as shown in the table in (3.2) from Ladefoged et al. (1998). Stress in Scottish Gaelic is almost always word-initial (Lamb 2001, Bosch 2010, Clayton 2010), with a few exceptions for loanwords and proper nouns. Like many other phonological processes in the language the vocalic contrast in length and nasalization favors stressed environments and is thus only present in the first syllable of the word (Gillies 2009, Ladefoged et al. 1998, Bosch 2010). In unstressed (i.e. non-initial) environments, all vowels are short and are not contrastively nasalized.

(3.2) Scottish Gaelic vowels (Ladefoged et al. 1998, pg. 4)

	Front	Central	Back	
			Unrounded	Rounded
High	i i: ï ï:		u u: ũ: ũ:	u u: ù ù:
High-Mid	e e:		ɤ ɤ:	o o:
Low-Mid	ɛ ɛ: ẽ ẽ:			ɔ ɔ: õ õ:
Low		a a: ã ã:		

There is also a set of ten diphthongs in the language which result from the breaking of Old Irish long vowels (Gillies 2009). Diphthongization processes are less common in the peripheral dialects, which are more likely to preserve the original monophthongs (Lamb 2001)

3.2.2 Consonants

Like Irish (Sutton 1992) and Manx (Draskau 2008), Scottish Gaelic has a phonological contrast between plain or velarized consonants, often referred to as “broad”, and palatalized consonants, often referred to as “slender” (Nance & Ó Maolalaigh 2019). These categories correspond to the language’s vowel inventory as well, with back vowels considered broad, and front vowels slender (Lamb 2001). Neighboring segments “harmonize” for this trait, with broad and slender consonants being bracketed by vowels of the same category (Konstantopoulos 1998). The contrast is more phonological than phonetic, however, as broad and slender consonants do not always correspond with an actual velarized or palatalized output and also behave differently depending on morphology (Stewart 2004, Hannahs 2011). The consonant inventory of the language and the broad/slender contrast is shown in the table in (3.3).

(3.3) Scottish Gaelic consonants (adapted from Ladefoged et al. 1998, pg. 3)

		Labial		Coronal		Velar		Glottal
		Broad	Slend.	Broad	Slend.	Broad	Slend.	
Stop	Unaspirated	p	p ^j	t	t ^j	k	k ^j	
	Aspirated	p ^h	p ^{hj}	t ^h	t ^{hj}	k ^h	k ^{hj}	
Fricative	Voiceless	f	f ^j	s	ʃ	x	ç	
	Voiced	v				ɣ	ɣ ^j	
Nasal		m		n n ^v	n ^j			
Lateral				l l ^v	l ^j			
Rhotic				r r ^v	r ^j (ð ^j)			
Approximant				j				h

While most consonants have a plain/palatalized distinction, the coronal sonorants also contrast in velarization, and in the case of /m/, /j/, and /h/ there is no broad/slender contrast. The dental /ð^j/ is a common realization of the palatalized rhotic /r^j/ in some dialects.

Scottish Gaelic is also known to display a number of interesting phonological phenomena, such as the lenition of stops into fricatives in certain morphological contexts (Stewart 2004, Hannahs 2011, Nance & Ó Maolalaigh 2019) and preaspiration in word-medial and -final aspirated stops (Ní Chasaide 1985, Dubach Green 1997, Clayton 2011, Nance & Stuart-Smith 2013). Like the vowel contrast in length and nasalization, these phonological processes are limited to the first syllable of the word due to the attraction of initial stress. In fact, the entire series of aspirated stops is essentially limited to the margins of the first syllable, with all stops neutralizing for aspiration in stress-free environments.

3.2.3 Phonotactics

Consonant clusters in Scottish Gaelic can be as long as three segments, with two being the most common configuration. Word-initially and in onset position, clusters can take the form of /s/ + voiceless obstruent + voiced sonorant, although these clusters are often reduced or simplified in word-internal positions. Word-finally and in coda position, CC clusters are the maximum length allowed and typically follow an /s/ + stop pattern (Wolters 1997). This phonotactic spread is typical of Goidelic languages and is almost identical to the system found in Irish (Ní Chiosáin 1999).

3.2.4 Prosody

As previously stated, stress in Scottish Gaelic is nearly always word-initial, and is frequently an attractor for various phonological processes and phonemic contrasts which are not evidenced elsewhere in the language. Many researchers conclude that beyond the

first syllable of the word, there is no secondary stress structure (Lamb 2001, Bosch 2010). The language, however, displays a typologically unique svarabhakti construction whereby epenthesized vowels do receive stress and are reduplicated from the vowel preceding (Bosch 2010, Nance & Ó Maolalaigh 2019). The presence or absence of an epenthetic stressed vowel creates a sort of lexical contrast which is comparable to a pitch accent, and may be attributable to the historical influence of pitch-accented languages like Old Norse (Iosad 2015). There is also evidence that stress in Scottish Gaelic interacts more complexly at the level of the phrase, with Adger (2007) identifying that lexical verbs often receive the only primary stress in the sentence.

3.3 Conclusion and rhythm predictions

Although Scottish Gaelic has been referred to as stress-timed (McCaughey 1984, Gillies 2009, Blankenhorn 2013), the rhythmic classification of the language has never been empirically tested. Gaelic does display many phonological and prosodic traits emblematic of stress-timed languages, such as complex consonant clusters, variable syllable structure, stress-related lengthening, and phonological processes and contrasts which are only present in stressed syllables. Most encouraging of all are the phonotactic and prosodic similarities found in Gaelic to its sister language Irish, which has previously been studied as stress-timed (Dorn et al. 2012). All of the prosodic, segmental, typological, and areal influences on Scottish Gaelic suggest that it will exhibit stress-timed durational patterns, and consequently the prediction is made that Scottish Gaelic will receive similar scores under a durational-metric analysis to other stress-timed languages such as English. This thesis will therefore analyze the rhythm of Scottish

Gaelic through durational metrics in order to identify whether the stress-timed categorization of the language can be responsibly extrapolated from the sum of its promising parts.

CHAPTER 4

DURATIONAL-METRIC ANALYSIS OF GAELIC

4.1 Overview

As previously stated, the phonological and prosodic profile of Scottish Gaelic is indicative of a stress-timed durational-segmental pattern, and the language has been labeled as stress-timed in multiple sources. This study will therefore analyze the rhythm metrics of Gaelic in order to confirm whether or not the language does display the segmental and durational patterns predicted by its typological features. For the sake of comparison and in order to ensure that my own methodology is internally consistent, I will also conduct a durational-metric analysis of English to measure against the Gaelic results. English has been treated as perhaps the most prototypical example of a stress-timed language, and so the metric scores calculated for English will be taken as the standard by which the Gaelic scores will be compared in order to determine its relative similarity to a stress-timed metric profile. It will also be observed whether the scores measured for English are similar to those previously found for the language.

To limit the scope of the study, I will only employ here an analysis of the durational metrics proposed by Ramus et al. (1999), %V (percentage of vocalic content), ΔV (standard deviation in vocalic interval length), and ΔC (standard deviation in consonantal interval length). Further work, however, could derive the PVI and Varco scores for the English and Gaelic data analyzed here as well, as the same measurement protocols used for %V, ΔV , and ΔC can also be applied to these other metrics.

4.2 Reason for analysis

This research into Scottish Gaelic is merited and necessary for a number of reasons. In the first place, it will contribute new information on the phonology of Gaelic, and will test whether the segmental-prosodic profile of the language – presumably the impetus for the prior classifications – is truly correlative with a stress-timed durational-metric makeup. If Gaelic measures out to be stress-timed it would lend credence to the theoretical conceptualization of what it means to be stress-timed, considering that on a perceptual and phonological basis the language should be expected to class with other stress-timed languages. If the scores of Gaelic were wildly different from those of English, it could suggest that these durational metrics are not able to capture whatever phonological characteristics contribute to the perception of a language as stress-timed, or that stress-timed rhythm is not a homogenous perceptual category. This study will also supply the durational-metric scores of a new language, thus adding to the existing repository of languages which have already been studied through durational metrics, and facilitating the comparative analysis of any future languages studied through this framework.

Before moving forward it must be acknowledged that although some view the relationship between durational metrics and rhythm as controversial, and that the labels of stress- and syllable-timed are somewhat problematic due to their roots in isochrony, the terms “rhythm class” and “stress-timed” will still be used here in reference to the categorizations with which they have traditionally been associated. This study would more accurately be labeled an analysis of segmental proportion and durational variability, as these are the properties more directly reflected by durational metrics, but for the sake

of relevance and reference to the large literature this will be considered a “rhythmic” analysis of Scottish Gaelic, with the expectation of confirming or falsifying its membership in a “stress-timed” rhythm class.

4.3 Methods

4.3.1 Data source

Both the Scottish Gaelic and English data used for analysis were taken from speech corpora comprised of conversational interviews in which the participants spoke for long periods of time in response to open-ended questions. Spontaneous speech such as this has been used for durational-metric analysis before (Lin & Wang 2007, Arvaniti 2012), and the Gaelic results will be measured against the English to check for consistency. The English data used here was initially collected for the purpose of phonetic analysis, which was not revealed to the participants until after they were interviewed, while the Gaelic data was collected for the purpose of language documentation, which the participants were apprised of beforehand.

The Scottish Gaelic data used for this study was taken from the Arizona/Nevada Scottish Gaelic Documentation Project of the University of Arizona (Clayton et al. 2015-2017). From the corpus, the data from four language consultants were selected based on the acoustic clarity of their recordings. All of them were native speakers of Scottish Gaelic, and their demographic information in the table in (4.1) As mentioned in section (3.2), all of the Gaelic speakers whose data were used for analysis were raised in the central dialect area.

(4.1) Scottish Gaelic speaker data

	Age	Gender
Consultant 1	50s-60s	Female
Consultant 2	60s-70s	Female
Consultant 3	50s	Male
Consultant 4	40s	Male

The English data used for this study was taken from the Buckeye Corpus of Ohio State University (Pitt et al. 2007). The speakers in the corpus were native speakers of English who had lived in Columbus, Ohio since childhood. Four of the speakers were chosen for analysis here, based on acoustic clarity and the abundance of uninterrupted, rhythmically typical speech in their data, with their demographic details given in the table in (4.2). The Buckeye Corpus indicates age by the categories of “young” and “old”, which are defined as “under thirty” and “over forty” respectively.

(4.2) English speaker data

	Age	Gender	Corresponding name in original corpus
Speaker 1	Young	Female	Speaker 1
Speaker 2	Old	Male	Speaker 3
Speaker 3	Young	Male	Speaker 6
Speaker 4	Old	Male	Speaker 10

4.3.2 Data collection

For each speaker of Gaelic and English an audio file of approximately 90 seconds was cut from a larger interview with the aim of gathering about one minute of segmental data. The usable data for each file varied somewhat due to pauses in the speech stream, mumbled or ambiguous speech, and exaggerated filler words such as ‘um’ and ‘and’ for

English and *agus* ('and') for Gaelic, which were not considered durationally typical and were thus omitted from segmentation.

The following table in (4.3) displays the length of the original audio files for English and Gaelic, as well as the total length of consonantal and vocalic intervals segmented from the speech. All segmented speech was from the speaker or consultant indicated, and not from the interviewer. As indicated in the table, the total vocalic and consonantal content segmented from the Gaelic was three minutes and 72 seconds from a combined audio source of six minutes and 32 seconds, while the total content segmented from the English was three minutes and 37 seconds from a combined audio source of six minutes and 13 seconds.

(4.3) Length of Gaelic and English segmentation files

		Segmental content (seconds)	Original length (seconds)
Gaelic	Consultant 1	63.42	96.00
	Consultant 2	60.01	96.54
	Consultant 3	55.66	90.67
	Consultant 4	43.67	95.86
	<i>Total:</i>	222.76 (3 min 72 sec)	379.07 (6 min 32 sec)
	<i>Average:</i>	55.69	94.77
English	Speaker 1	45.57	94.59
	Speaker 2	34.65	91.27
	Speaker 3	60.02	91.59
	Speaker 4	62.29	90.00
	<i>Total:</i>	202.53 (3 min 37 sec)	367.86 (6 min 13 sec)
	<i>Average:</i>	50.63	91.86

4.3.3 Segmentation

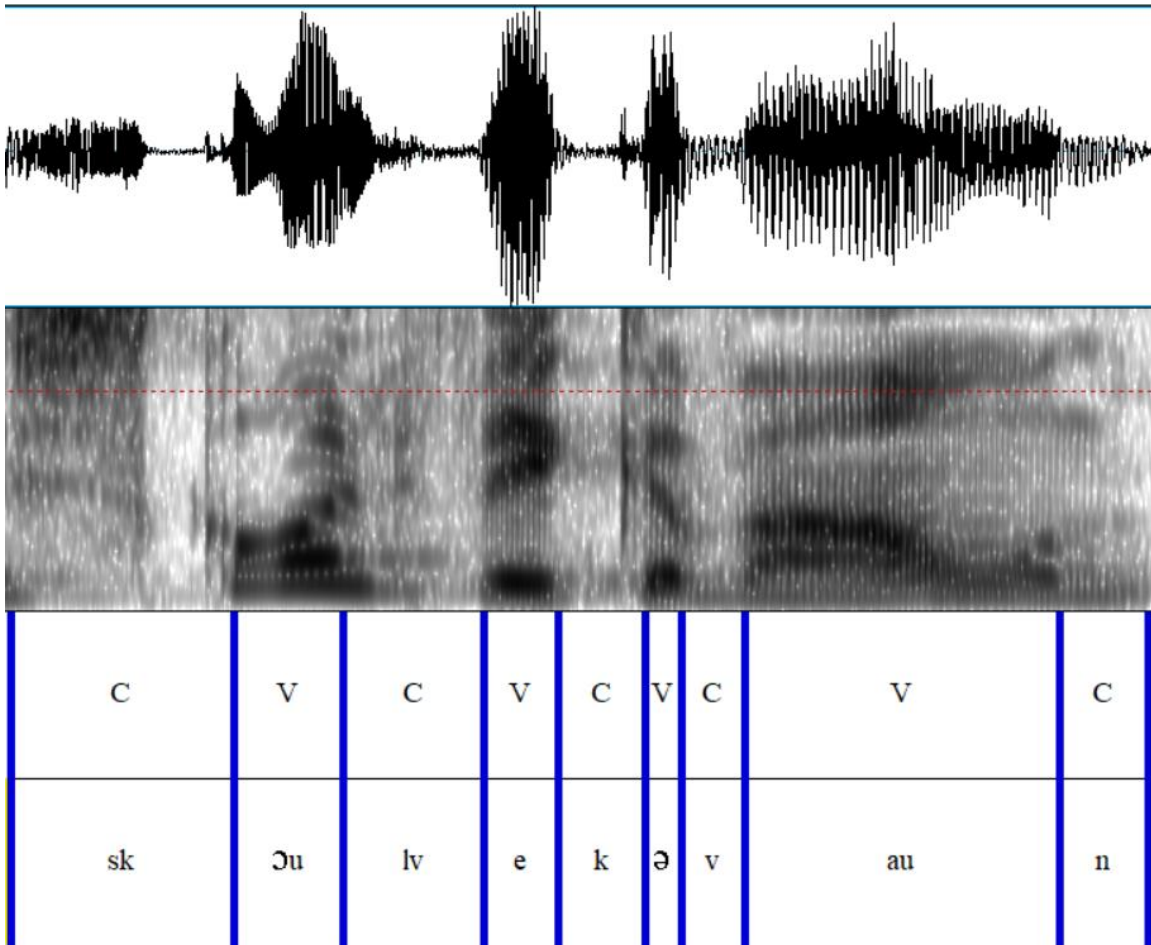
One of the flaws of durational metrics is that vocalic and consonantal interval boundaries are not always easily distinguishable from each other, but metrics force a

categorical judgment of such boundaries without allowing for any gradience or coarticulation. Furthermore if speech segmentation is a discrimination strategy employed by infants, as suggested by Ramus et al. in their original publication (1999), then it doesn't seem evident that an infant would, for instance, be able to make the essentially phonological distinction between vocalic and non-vocalic sonorant elements. However these are precisely the distinctions which must be made in the practice of durational-metric segmentation, and consequently a number of methodological choices arise.

Firstly, in maintaining the practice of Ramus et al. (1999) and of many subsequent studies, I considered “glide” elements in the data to be consonantal in onset position and vocalic in coda position, a choice which is also consistent with phonotactic constraints of English and Gaelic. In the case of all consonantal sonorants, and especially non-nasal sonorants such as laterals and rhotics, it was often difficult to identify a clear division between the end of the consonant and the beginning of the vowel, and so an interval boundary was often placed at the impressionistic center of the two segments. Plosives were measured from the moment of closure to the moment of release, with the exception of phrase-initial plosives where the moment of closure was not distinguishable from the preceding silence.

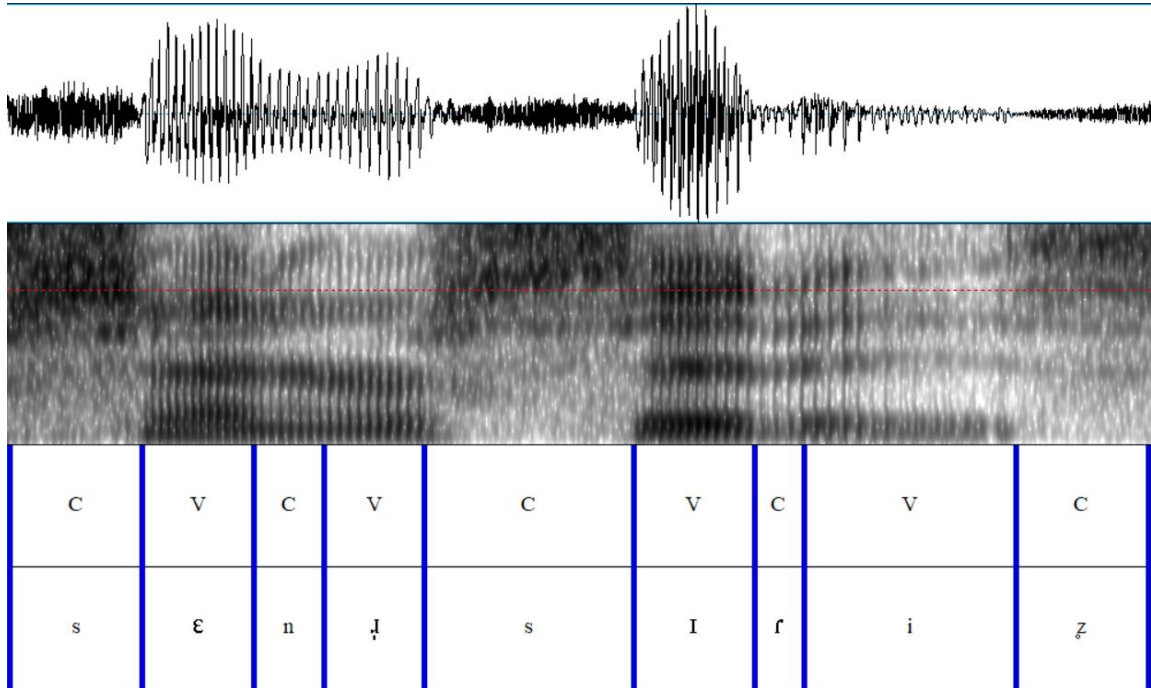
All data used for the project were segmented in the phonetic analysis software program Praat (Boersma & Weenink 2020). A Praat snipping of the Gaelic segmentation is shown in the figure in (4.4). The clip is from Consultant 2, and corresponds to the phrase *sgoil bheag a bh' ann* ('it was a small school'). A rough IPA transcription has been added to the image here, but such transcriptions were not inputted throughout the segmentation process.

(4.4) Snipping of Praat segmentation for Gaelic



A Praat snipping of the English segmentation is shown in the figure in (4.5). The clip is from Speaker 2 and corresponds to the phrase ‘center cities’. As in the figure in (4.4), an IPA transcription has been added.

(4.5) Snipping of Praat segmentation for English



The vocalic and consonantal interval start times and end times were extracted from Praat and copied into Microsoft Excel, and were then subtracted against each other to find the duration of each interval. The durational metric %V was then calculated by dividing the total duration of vocalic intervals by the total duration of segmental intervals overall, while the ΔV and ΔC metrics were obtained by calculating the standard deviation of the vocalic and consonantal interval durations, respectively.

4.4 Results

The %V, ΔV , and ΔC metric scores calculated for English and Gaelic are shown in the table in (4.6), along with the average scores for each language. Following the practice of Ramus et al. (1999), the ΔV and ΔC scores have been multiplied by 100 for the sake of readability.

(4.6) Durational-metric score results

		%V	ΔC	ΔV
Gaelic	Consultant 1	49.98	6.91	8.33
	Consultant 2	45.52	4.91	5.81
	Consultant 3	48.06	5.58	5.86
	Consultant 4	44.68	4.79	4.65
	<i>Average:</i>	47.06	5.55	6.16
English	Speaker 1	44.63	5.36	4.53
	Speaker 2	49.20	5.08	4.80
	Speaker 3	48.02	7.11	7.17
	Speaker 4	50.07	5.04	5.96
	<i>Average:</i>	47.98	5.65	5.62

The average %V scores for Gaelic and English are 47.06 and 47.98 respectively, the average ΔC scores are 5.55 and 5.65 respectively, and the average ΔV scores are 6.16 and 5.62 respectively. From these results it can be seen that the average scores for each metric are remarkably similar between the two languages, indicating a high degree of durational-metric uniformity.

Consultant 1 in the Gaelic group and Speaker 3 in the English demonstrate the highest metric scores for ΔC and ΔV , which was likely due to the relatively slower and more modulated speech rate they employed. In addition, for all of the Gaelic speakers there seems to be a general trend that a comparatively high score for one metric correlates with higher scores for each metric – if the Gaelic speakers are arranged in descending order of %V (Consultant 1, then 3, then 2, and then 4), the ΔC and ΔV scores are shown to simultaneously descend as well. This pattern is not replicated in the English scores, but the Gaelic results taken alone provide evidence for the tendency of durational metrics to correlate across the board, lowering together and raising together as they similarly respond to changes in register and speech rate.

4.5 Discussion

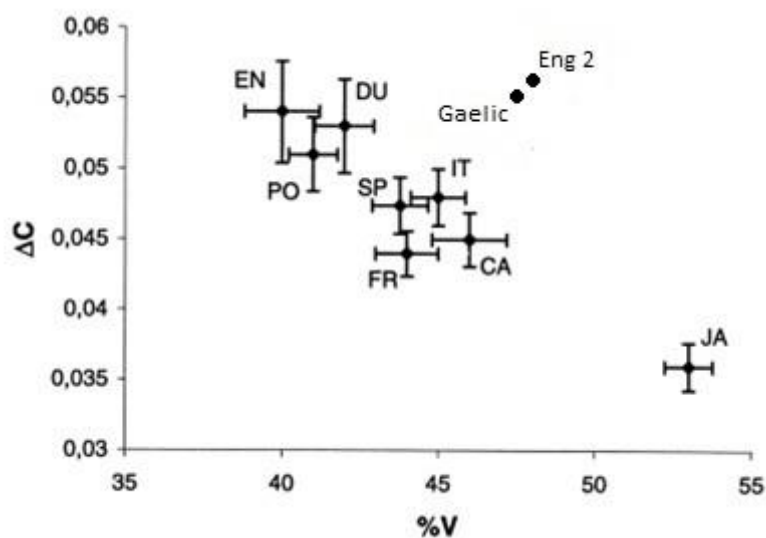
4.5.1 Internal analysis

The most crucial takeaway from this durational-metric analysis is that the average scores for English, a prototypically stress-timed language, and those for Gaelic, a language previously unanalyzed for rhythm class, are very similar. This lends substantial credence to the prior references to Scottish Gaelic as stress-timed, by demonstrating that the language does display similar patterns of durational variability and segmental proportion to English, a prototypically stress-timed language. Taken by themselves these results may not seem surprising, especially in light of the multitudinous phonological, prosodic, typological, and areal influences on Gaelic which all point towards a stress-timed classification. However, they are actually quite significant when considering the wider literature on rhythm classes, which has often failed to derive similarly predictable conclusions from equally promising sources. The fact that these results can identify Scottish Gaelic as stress-timed is something of an achievement, as the durational-metric analyses of other languages have rendered them essentially unclassifiable within the rhythm class framework (e.g. Grabe & Low 2002), suggesting that the segmental structure of Gaelic places it within a narrow durational-metric window in which the stress-timed/syllable-timed dichotomy can operate. And insofar as durational metrics are concerned, if this analysis of Gaelic were observed in a vacuum it would be considered persuasive evidence for their legitimacy as reflectors of rhythm class, as Gaelic and English are both languages with an impressionistically stress-timed rhythm.

4.5.2 Comparison to previous metric scores

Given how similar the metric scores for English and Gaelic are in this study, it is somewhat surprising to compare them with the metric scores found for the stress-timed languages in Ramus et al. (1999). While the ΔC score Ramus et al. found for English (5.35) is similar to the English score in this study (5.65), the difference in ΔV is greater (4.64 in Ramus et al. and 5.62 here) and the difference in %V is significantly greater (40.1 in Ramus et al. and 47.98 here). In fact, a %V score of 47.98 is higher than the syllable-timed languages and would place English somewhere between a syllable- and mora-timed classification for that metric. The Scottish Gaelic scores have a similar pattern, with the ΔC score for Gaelic (5.55) comparable with the other stress-timed languages in Ramus et al., but the %V score (47.06) being much higher. Ramus et al.'s grid for %V and ΔC is shown again in the figure in (4.7), now including the rough position for the English and Gaelic scores as measured in this study. The new scores for English are labeled as "Eng 2", while the Scottish Gaelic scores are labeled as "Gaelic".

(4.7) %V- ΔC grid (Ramus et al. 1999) with new scores for English and Gaelic



In observing the disconnect between the English and Gaelic scores measured in this study and the scores measured for stress-timed languages in 1999, it is tempting to assume some fundamental inconsistency between my methodology and that of Ramus et al. However a wider search reveals that these results are not inconsistent with the literature on rhythm classes, and can be easily explained by the difference in register between the two studies.

As previously discussed, one of the inadequacies of durational metrics according to Arvaniti (2009, 2012) is their sensitivity to elicitation. In her study on the usefulness of metrics (2012), she analyzed the metric scores for four languages in three different registers – sentence reading, story reading, and spontaneous speech. Sentence reading, the most controlled and artificial of these, consistently rendered among the lowest %V and ΔC scores for all the languages measured. Spontaneous speech on the other hand, the least controlled and most variable register, consistently rendered among the highest scores. As might be imagined, sentence readings comprised the data for Ramus et al., whereas spontaneous speech comprised the data for this study, and the difference in %V scores between the two studies can therefore be said to result from the choice in material. To illustrate this point, the table in (4.8) displays the %V and ΔC scores for English in Ramus et al. (1999) and Arvaniti (2012), alongside the measurements found in this analysis.

(4.8) English metrics compared with Arvaniti (2012) and Ramus et al. (1999)

	Ramus et al. (1999)		Arvaniti (2012)		This study	
	%V	ΔC	%V	ΔC	%V	ΔC
Spontaneous speech			48	6.8	48	5.7
Sentence reading	40	5.4	45	5.7		
Story reading			44	5.4		

In comparison to Ramus et al., Arvaniti finds higher %V scores for English across the board, never replicating the 40.1 score calculated in the 1999 study. More saliently, however, is the fact that the %V score for spontaneous speech in Arvaniti’s study is equivalent to the %V found for English in this study. Spontaneous speech has therefore been demonstrated to be higher in vocalic content in comparison to other elicitation methods, so it should not be especially surprising that the %V calculated for English in this study is noticeably higher than the %V calculated by Ramus et al., as they were segmenting controlled sentence readings whereas this study employed the segmentation of spontaneous speech.

The English scores calculated in this study are therefore similar to those found in previous metric analyses, and can therefore be considered credible measures of durational variability and segmental proportion in the language. As a result, they also legitimize the Scottish Gaelic scores by demonstrating a high degree of metric regularity between the two languages, and strengthen the rhythmic classification of Gaelic as stress-timed.

4.6 Conclusion

This metric analysis of Scottish Gaelic has displayed clear evidence for the stress-timed classification of the language by its comparative similarity to the prototypically

stress-timed English. The near-equivalent metric scores between the two languages provide strong evidence for similar patterns of durational variability and segmental proportion, and insofar as durational metrics say anything about rhythm class, these results also identify Gaelic and English as rhythmically similar. These results are supported by the larger literature which has reported similar durational-metric scores for English before, particularly in the register of spontaneous speech. Because the English scores calculated here are comparable to those previously found, it can also be surmised that the Scottish Gaelic scores are methodologically consistent and provide an accurate representation of the durational-segmental profile of the language. We can therefore conclude that Scottish Gaelic displays similar patterns of durational variability and segmental proportion to stress-timed languages such as English, and can be satisfactorily categorized as stress-timed under a conservative interpretation of the rhythm class framework.

CHAPTER 5

CONCLUSION

The results of this study have clearly shown that Scottish Gaelic displays patterns of durational variation and segmental proportion similar to those of English, a prototypically stress-timed language. The metric scores for %V, ΔV , and ΔC were shown to be very similar between the two languages, and also consistent with previous durational-metric analyses of spontaneous speech. The classification of Scottish Gaelic as stress-timed is therefore justified, as first predicted by the phonological and prosodic traits which place it in company with other stress-timed languages, and as subsequently demonstrated by the durational-metric analysis of the language here. Further work could also analyze the metrics of Scottish Gaelic through PVI and Varco scores, as well as through other elicitation methods such as sentence and story reading, to determine if these measures likewise support the rhythm classification of the language. And finally, the language could also be further studied, along with any number of other languages, through the more contemporary methods of rhythmic analysis which continue to emerge in the wake of the controversy over durational metrics.

Although this study should not be taken as a general defense of durational metrics as a measure of rhythm class, it certainly does provide positive evidence for the cross-linguistic consistency of metric scores and their correlation with perceptual rhythmic quality, which is often not deducible from the results of other similar analyses.

Durational metrics can be valuable and interesting within a narrow scope of analysis, but they should never be considered empirically legitimate and realistic measures of language rhythm more properly. It is possible that they may correlate with segmental and prosodic

characteristics which have traditionally been ascribed to certain rhythm classes, but it is not even clear whether such rhythm classes objectively exist, or whether their associated entailments have anything to do with actual language rhythm. The results for this study should therefore not be considered especially representative of the larger literature on durational metrics, as rarely does their application render such methodologically clear and interpretable results. However, it remains true that durational metrics are not inherently meaningless – it is possible that they provide some incidental correlation with language rhythm to a degree, but even if they say nothing about rhythm class they still provide insight on patterns of durational variation and segmental proportion.

In the context of this study, however, the usage of durational metrics has proven fruitful, and has clearly demonstrated that the segmental properties of Scottish Gaelic are indicative of a stress-timed character. There is still a great deal to learn about the rhythmic structure of Gaelic and English, and also about the rhythmic structure of any language, as the facts of perceived language rhythm remain so elusive. For the present, however, this study has provided a valuable contribution to the understanding of Scottish Gaelic phonetics and phonology, and has conducted a promising initial study on the rhythm class of the language by demonstrating its clear durational-metric similarity to English and its probable classification as stress-timed.

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