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THE PROSODY OF BARRA GAELIC EPENTHETIC VOWELS

Anna Bosch and Kenneth de Jong
University of Kentucky and *Indiana University*
engbosch@ukcc.uky.edu / kdejong@indiana.edu

Recent treatments of Barra Gaelic vowel epenthesis (Clements 1986; Ni Chiosain 1994; Halle 1995) address the location and identity of the epenthetic vowel, but do not address the previously reported prosodic properties of these vowels. This paper reports on a quantitative analysis of approximately 100 tokens from field recordings of Barra Gaelic (BG). Vowel duration, f_0 pattern, and vowel formant values were examined and compared between epenthetic and non-epenthetic vowels. Each of these examinations suggests that epenthetic vowels bear stress. The analysis of vowel formant values indicates that the identity of the epenthetic vowel is predictable on the basis of the previous vowel and sonorant consonant, as reported in the descriptive literature. Thus, epenthetic syllables in Barra Gaelic represent a case in which historically epenthetic, yet prominent syllables bear information previously specified on less prominent neighboring syllables.

1. Introduction

Most Hebridean dialects of Scottish Gaelic have historically epenthesized vowels between non-homorganic sonorants and obstruents, following a short, stressed vowel. In each of these dialects the presence and the quality of this vowel is entirely predictable. Examples of this process are shown in (1).[1] Recent synchronic treatments of historically epenthetic vowels in Barra Gaelic (BG) (Clements 1986, Ni Chiosain 1991, Halle 1995) focus on the location and identity of the epenthetic vowel. However, these analyses fail to adequately address Borgstrøm's claim that, though stress is otherwise only word-initial, epenthetic vowels seem to share stress with the preceding vowel. Other prosodic properties also distinguish the epenthetic vowel from non-epenthetic vowels in similar environments.

(1)	/arm/	→	[aram]	'army'
	/dɔrɣ/	→	[dɔrɔɣ]	'fishing line'
	/dʲaɫv/	→	[dʲaɫav]	'a picture'
	/ʃaɫv/	→	[ʃaɫav]	'prosperity'
	/merʲkʲ/	→	[merʲekʲ]	'rust'
	/skarv/	→	[skarav]	'cormorant'
	/baɫk/	→	[baɫak]	'mushroom'
	/ʃaɫk/	→	[ʃaɫak]	'hunting'
	/tʰʲiLʲkʲəɣ/	→	[tʰʲiLʲikʲəɣ]	'to throw'
	/ɛrʲkʲət/	→	[ɛrʲɛkʲət]	'silver, money'
	/urxirʲ/	→	[uruxirʲ]	'a shot'

/aɫpə/	→	[aɫapə]	'Scotland'
/ʃaɫkɛrʲ/	→	[ʃaɫakɛrʲ]	’hunter’
/kʰarpət/	→	[kʰarapət]	’car’
/dɔrxɔ/	→	[dɔrɔxɔ]	’dark’
/duʁxəɣ/	→	[duʁuxəɣ]	'Duncan'
/tʰɔrmɛt/	→	[tʰɔrɔmɛt]	'Norman'

In fact, these prosodic properties constitute the major clue that there is a difference between epenthetic and non-epenthetic vowels. To illustrate this point, note that non-epenthetic vowels can also appear between a non-homorganic sonorant and obstruent following a stressed vowel, as is illustrated in (2). (2) shows examples in which the second vowel appears in the environment required for epenthesis and is the appropriate vowel inserted by the epenthesis rules proposed in previous analyses (e.g., Clements 1986, Ni Chiosain 1991, and Halle 1995); however, the second vowel in these words is not epenthetic. Thus, if one only pays attention to segmental transcriptions, the epenthesis process is a neutralizing, morpheme-internal process. This leads us to inquire whether contemporary speakers of BG distinguish between epenthetic and non-epenthetic vowels.

(2)	[aran]	’bread’
	[ʃɛʀɔx]	’foal’
	[fɛʁak]	’crow’
	[miʎəɣ]	’to destroy’
	[kʰaʎɔx]	’old woman’
	[ʃilʲəɣ]	’to rain’
	[kʰalʲak]	’young girl’

Several phonetic and phonological differences between epenthetic and non-epenthetic vowels distinguish them from one another.[2] The main published source for data on Barra Gaelic is Borgstrøm's (1937) study; that study notes that epenthesis creates syllables which are markedly different from non-epenthetic syllables in three ways (see also Bosch, 1991).

1. Although stress is regularly word-initial in Scottish Gaelic, Borgstrøm notes that the epenthetic vowel is perceived to have stress equal to that of the initial stressed vowel, and level pitch with the initial vowel.

2. The epenthetic vowel demonstrates the same vowel inventory as is found in the initial, stressed syllable; in non-epenthetic, unstressed syllables this inventory is restricted in BG.

3. Borgstrøm also claims a difference in syllabification between ordinary disyllables and words involving an epenthetic vowel: non-epenthetic disyllables, it is claimed, syllabify an intervocalic consonant to the left, as a coda (CVC.VC, e.g., [ar.an] ‘bread’); disyllables formed with an epenthetic vowel place the intervocalic consonant to the right (CV.CVC, e.g., [a.ram] ‘army’). (See also Bosch, 1997, for a review of other Gaelic studies claiming VC.V syllable structure.)

Unless our analysis of Barra Gaelic epenthesis accounts for the prosodic properties of the epenthetic vowel, as well as accounting for its location and identity, we fail to identify epenthesis as anything other than an historical sound change. The aim of the present research is, then, to characterize the prosodic difference between these epenthetic and non-epenthetic vowels, and then to relate these prosodic differences to the vowel epenthesis phenomenon itself. The main focus of the current paper is to examine quantitative evidence bearing on the first claim of Borgstrøm, that epenthetic vowels bear stress. Future research will address the question of how syllable structure is involved in the prosodic organization.

2. The study

This paper reports on a quantitative analysis of field recordings of Barra Gaelic. Recordings were made in the speaker's residence in Castlebay, Isle of Barra with an Uher reel-to-reel tape recorder. The speaker was an elderly Gaelic male, a native of the Isle of Barra. The first 102 CVRVC tokens in the recordings were digitally extracted from longer conversations including the relevant items. Several repetitions of each word were obtained in the process of elicitation.

Several aspects of the corpus should be born in mind. First, this corpus consists of a fairly irregular collection of consonant and vowel types; hence some of the relevant comparisons are not available in this data set. Second, there was a considerable amount of phonetic variability in the corpus (not unlike normal speech), since the speaker varied from an emphatic rendition (to help the transcriber) to a repeated, highly lenited form. Third, these tokens were embedded in a large number of other tokens, so there is little chance that the speaker knew that the epenthetic tokens were of special interest.

Acoustic analyses were performed using SoundScope implemented on a Macintosh PC. Vowel and consonant durations were measured using broad-band (184 Hz) spectrograms and aligned waveforms. Vowel onsets and offsets were determined as the onsets and offsets of energy through a broad portion of the spectrum. Vowel duration measures have been found to strongly correlate with the presence of stress in a large number of studies. (See Fry, 1955 for a conclusive, early documentation of this effect in English.) Fundamental frequency patterns were also examined by means of an autocorrelation routine. Stress in English has also been found to be strongly cued by differences in fundamental frequency pattern (Fry, 1958) which have been analyzed as being due to the typical association of pitch accents to the stressed syllables (Bolinger, 1958; Pierrehumbert, 1980; see also Bruce, 1977 for a similar analysis of Swedish).

In addition, to verify previous claims concerning the epenthetic vowel identity, formant values were also estimated at the temporal mid-point of the first and second vowel in each token. Formant estimates were obtained using a 12th order LPC analysis. Values produced by this technique were checked against formant estimates taken visually from the spectrograms, and in cases where the LPC analysis failed to detect a formant peak, estimates were made from the spectrogram.

3. Results

3.1 Vowel durations

First, we examine vowel durations. To present the data, we plot the duration of the first vowel (V1) against the duration of second vowel (V2). Since the conditions for epenthesis only arise following the first (stressed) syllable of a word, epenthetic vowels always occur as V2. Figure 1 lays out the types of effects available from such a plot. Differences in the vertical direction indicate a longer initial vowel (top left panel); differences in the horizontal direction indicate a longer target (second) vowel (top right panel). Thus, for example, if epenthetic vowels were short, excrescent vowels, one would expect them to appear to the left. However, if they're longer, one would expect them to appear to the right. This kind of a plot also allows some implicit rate normalization: tokens which separate in a dimension parallel to the x = y diagonal axis differ in general rate (lower left panel), slower tempos would lengthen both vowels and tokens would appear more upward and to the right. The dimension perpendicular to this axis indicates a relative difference between the first and second vowel, such as would be captured by V1 - to - V2 ratios (lower right panel).

Figure 1. Schema of types of effects visible on a V1 duration X V2 duration plot.

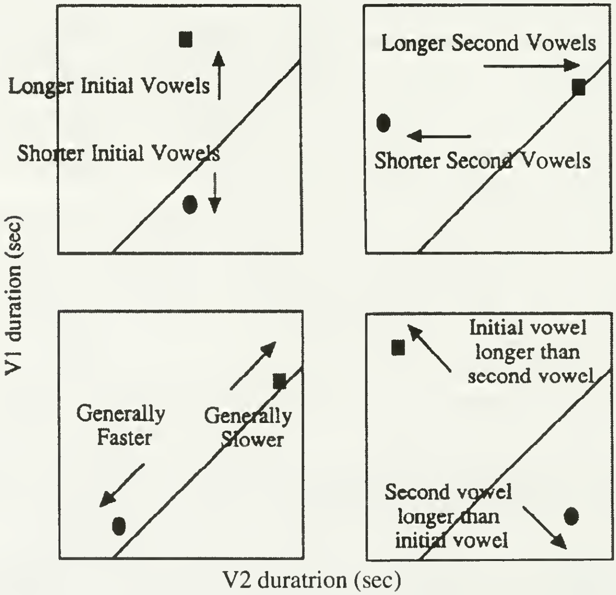
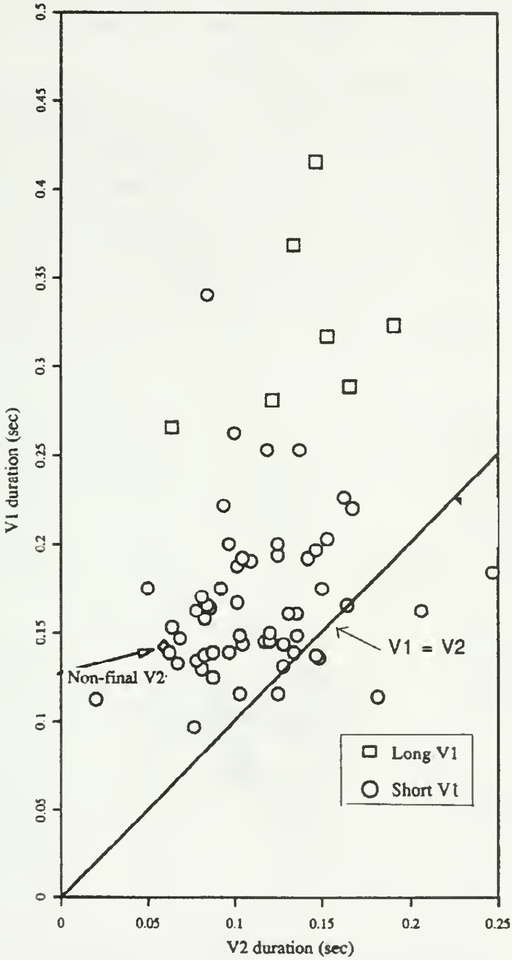


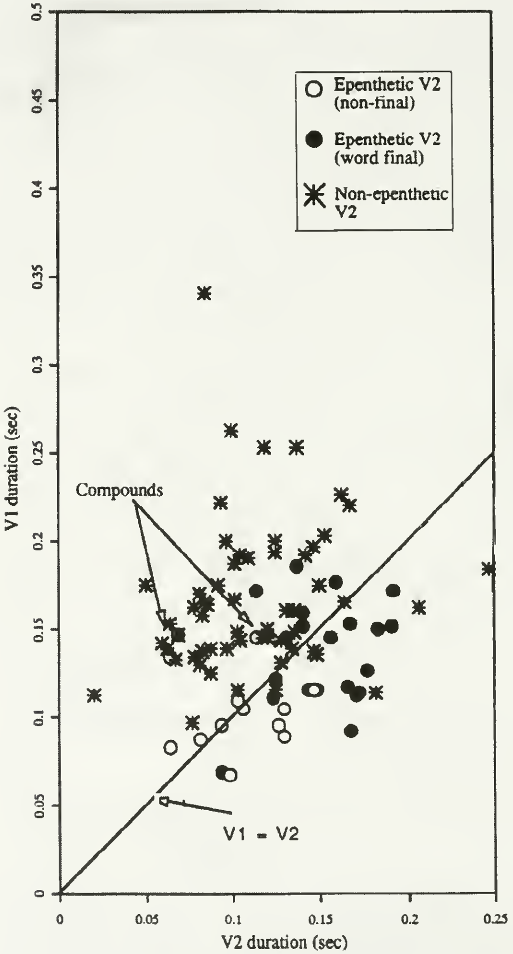
Figure 2 shows only non-epenthetic tokens. Here, it is quite apparent that V1 is longer than V2 (since most tokens lie above the x=y line). This is what one would expect with stress on initial syllables. In the stressed initial syllable, we do find a contrast in vowel length: phonologically long vowels are indicated with square boxes.

Figure 2. V1 duration plotted against V2 duration for non-epenthetic tokens.



Note here that while long V1's are indeed longer than short V1's, following vowels do not seem to be influenced by the length of V1 (i.e., V2's are not consequently shorter, or indeed longer--they seem to show the same range of duration as V2's following short V1's). These observations are confirmed by the results of one-way Analyses of Variance (ANOVA's) with V1 quantity as an independent variable and V1 and V2 duration as dependent variables (V1: F(1,62) = 77.56, $p < 0.001$; V1: F(1,62) = 2.99, $p > 0.05$). One final item of note in Figure 2 is the single trisyllabic token indicated down and to the left. The positioning of this token to the left suggests that the reason so many tokens stray across the x=y function to the right is final lengthening. Each of these tokens are disyllables in which V2 is final, often final to the utterance.

Figure 3. V1 duration plotted against V2 duration for all tokens with a short V1.



In Figure 3, we add the epenthetic tokens. (Tokens with long vowels have been omitted from this figure, since epenthesis does not occur after phonologically long vowels.) Here, the non-epenthetic tokens are coded as stars, and the epenthetic tokens are coded as circles. Two epenthetic conditions are noted; filled circles are disyllabic, hollow circles are polysyllabic. Two results are of note here. First, there is a clear separation of epenthetic and non-epenthetic tokens in the diagonal dimension. In general, epenthetic tokens fall along or below the x=y line, while non-epenthetic tokens are usually above the line. Thus, epenthetic vowels are systematically longer than their non-epenthetic counterparts. In addition, vowels previous to epenthetic vowels are shorter than their non-epenthetic counterparts.

Second, this pattern is somewhat complicated by final-lengthening. Comparing filled circles (where V2 is final) and hollow circles (where V2 is medial), one finds word final vowels are longer (further to the right). Since most of the non-epenthetic V2's are final, we see some mixing of them with epenthetic tokens. These durational patterns, then, indicate two sizable durational effects on V2, one associated with the final lengthening, and the other associated with the epenthetic/non-epenthetic distinction. The durational data suggest strongly that while Barra typically places stress on initial syllables, words with epenthetic vowels exceptionally bear stress on the epenthetic syllable. Initial vowels in tokens with epenthetic vowels exhibit a reduced stress level, as indexed by vowel duration measures.

Table 1. Summary of ANOVA's. * and bold face indicates significant results.

Independent Var.	d.f.	F-value	P-value
		Dependent Var. =	Duration of V1
epenthetic?	1	1.41	0.24
disyllable?	1	0.29	0.59
ep? X disyll?	1	0.28	0.60
residual	87		
		Dependent Var. =	Duration of V2
epenthetic?	**1**	**4.20**	**0.04***
disyllable?	**1**	**4.10**	**0.04***
ep? X disyll?	1	0.50	0.48
residual	87		
		Dependent Var. =	V2/V1
epenthetic?	**1**	**9.30**	**0.003***
disyllable?	1	2.34	0.13
ep? X disyll?	1	0.16	0.69
residual	87		

These observations are supported by two-way ANOVA's with binary variables indicating whether the word is a disyllable and whether the second vowel is epenthetic as independent variables, and vowel durations (Vl and V2) and the ratio of V2 to Vl as dependent variables. The results of this analysis are shown in Table 1. The duration of the second vowel is affected both by final lengthening and whether the vowel is epenthetic. When we do implicit rate normalization by taking the ratio of V2 to Vl, it becomes apparent that the epenthetic effect on V2 is combined with a subtle difference in Vl which was obscured by the rate and other temporal variation in the sample.

3.2 Phonemic Inventory

This conclusion, that epenthetic syllables are exceptionally stressed non-initial syllables, fits in nicely with the observation that epenthetic vowels select from the larger inventory of vowels in stressed initial syllables, rather than the reduced inventory found in non-initial unstressed syllables. The entire nine vowel inventory shown in (3) is found both initially and epenthetically, whereas unstressed (non-initial, non-epenthetic) syllables contain the reduced inventory of vowels given in (4).[3]

(3)

	Front		Back
High	i	ɯ	u
Mid	e	ə	o
Low	ɛ	a	ɔ

(4)

	Front		Back
High	i		u
Mid		ə	
Low	ɛ	a	ɔ

3.3 Tonal Patterns

Epenthetic vowels also have been noted in the descriptive literature to have a different pitch pattern than vowels in non-epenthetic second syllables. A cursory investigation of fundamental frequency (F_0) contours also supports our contention that epenthetic vowels bear stress.

Figure 4 shows a waveform of a token without an epenthetic vowel, one rendition of the word [anəm], meaning ‘soul’, with a time-aligned F_0 plot. This figure shows a clear F_0 peak on the initial syllable and a gradual fall to a terminal low. This pattern is found throughout the corpus, and can be phonologically represented by the association of a high pitch accent to the stressed first syllable.

Pitch tracks of epenthetic tokens show later F_0 peaks. Figure 4 shows an F_0 plot of a rendition of [ɛɲɛm], ‘name’. It shows an F_0 peak localized somewhere near the beginning of the second syllable and a sharp fall to the terminal low. This pattern is also found with epenthetic tokens throughout the corpus, though tokens do not always exhibit such a sharp fall. A possible representation of this structure is as a HL (falling) accent associated with the exceptionally stressed second syllable.

Figure 4. Spectrogram and fundamental frequency plot for a token without an epenthetic vowel, [anəm] 'soul'.

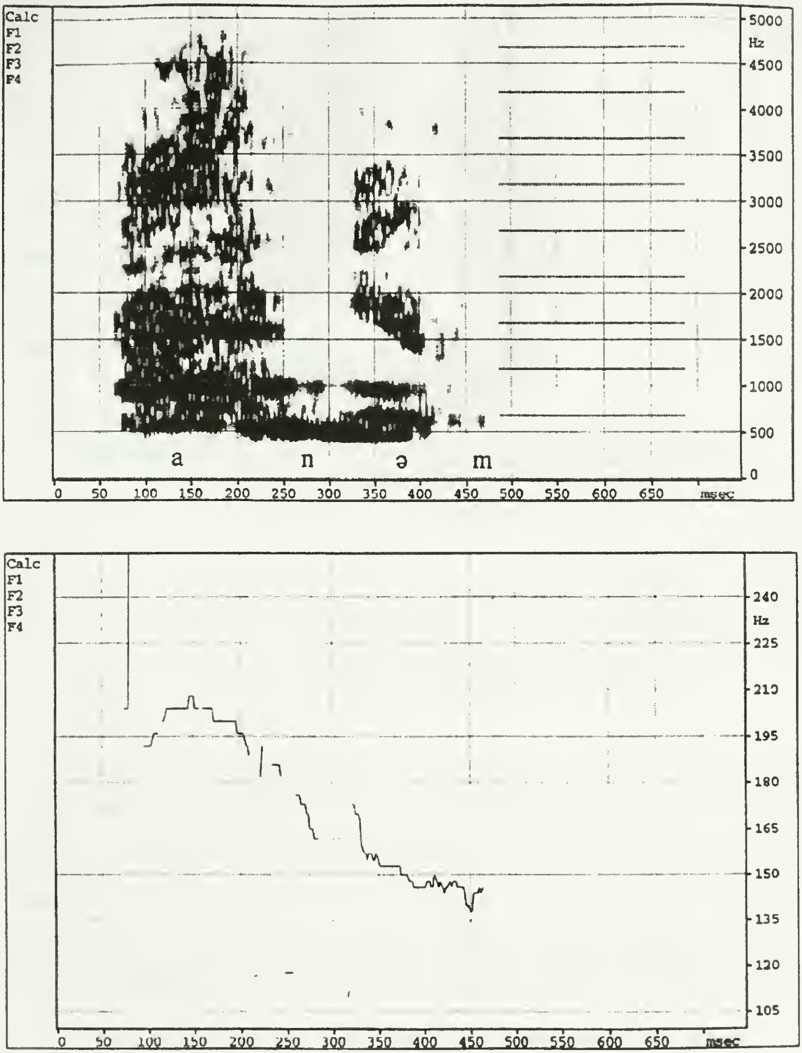
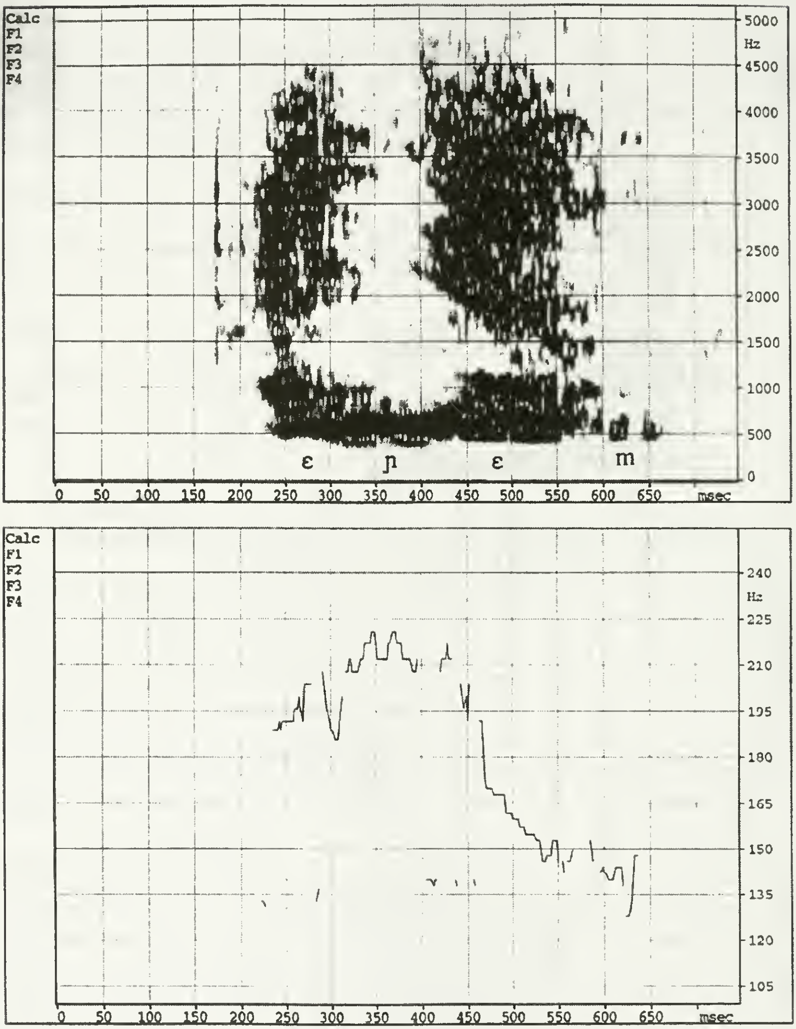


Figure 5. Spectrogram and fundamental frequency plot for a token whose second vowel is epenthetic, [ɛɲɛm] 'name'.



Additional evidence for treating these pitch patterns as indicative of stress-related pitch accents comes from words with an epenthetic vowel occurring as the second element in a compound. In Figure 3, in the cluster of non-epenthetic tokens there are three exceptional epenthetic tokens indicated in the lower left. Each of these is a token of [fɛrɛɲɛm], meaning "nickname," a compound made up of [fer] + a morpheme with an epenthetic vowel [ɛɲɛm] (the same morpheme occurring in Figure 5). Thus, as a second member of a compound, an epenthetic token seems to have the same durational pattern as a non-epenthetic token. Figure 6, a pitch track of one of these compound tokens, indicates high F_0 on the initial syllable of the compound and low F_0 throughout the second element of the compound. This pitch pattern is found in each of the tokens. Thus, the accent apparent in Figure 5 does not appear when the same morpheme is the second member of a compound.

This tonal behavior can be captured in a prosodic theory such as that presented in Pierrehumbert & Beckman 1988 with three constraints: 1) pitch accent can only associate with stressed syllables, 2) only one pitch accent is allowed per phonological word, and 3) stress is restricted to the first two syllables of the word. The culminative structure, of which constraint 1 is a part, can be expressed in metrical grids. (5) shows appropriate grids for the three utterances in Figures 4 - 6, [anəm] with stress and accent on the first syllable, [ɛɲɛm] with stress and accent on the second, and the compound with no stress or accent on the epenthetic second vowel of [ɛɲɛm].

(5)	accent	X			X	X		
	stress	X		X	X	X	X	
	syllable	X	X	X	X	X	X	X
		a n ə m		**ɛ ɲ ɛ m**		**f ɛ r ɛ ɲ ɛ m**		
		non-epenthetic		epenthetic		compound		

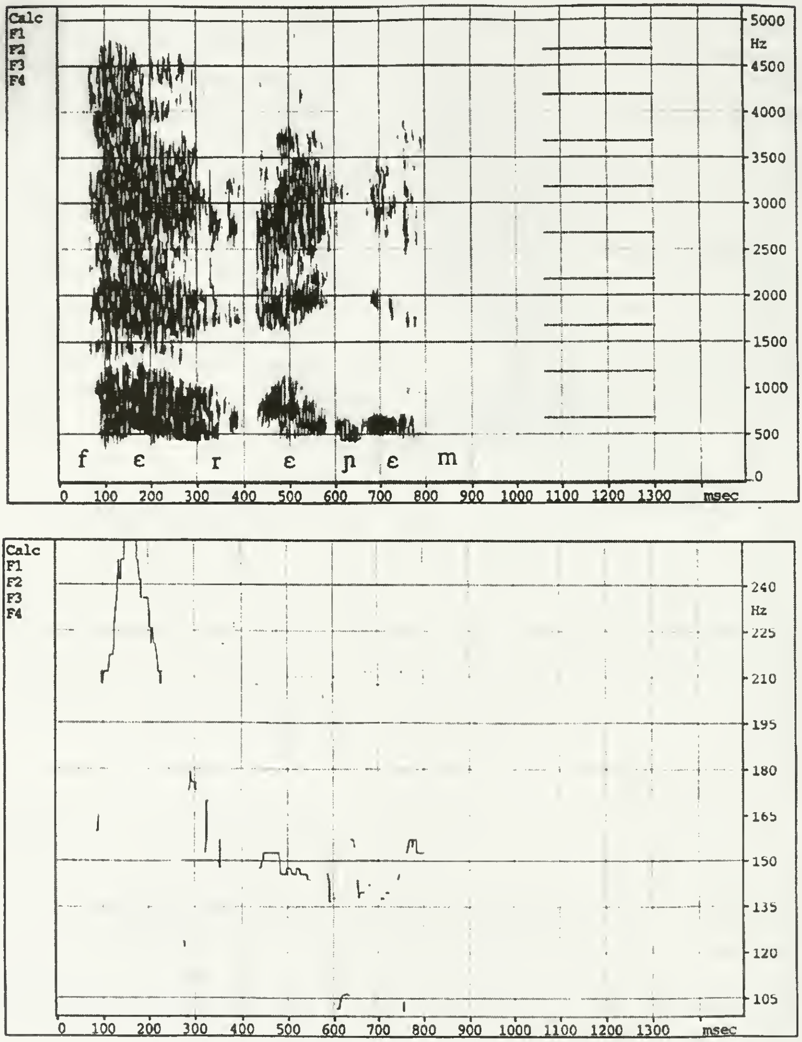
In summary: epenthetic vowels demonstrate a higher fundamental frequency than non-epenthetic V2's, apparently indicative of an associated pitch accent. These observations combine with observations concerning vowel duration and phonemic inventory to support the contention that the epenthetic vowel is stressed, partially at the expense of the preceding, initial vowel.

3.4 Vowel Quality

We turn to the results of the analyses of epenthetic vowel quality. Feature geometry analyses (Ni Chiosan, 1994; Halle, 1995) identify the epenthetic vowel as a copy of the previous vowel, except that the back feature of the vowel is determined by the secondary articulation on the previous sonorant consonant. Consonants in Scottish Gaelic are categorized as either palatalized or non-palatalized. In these accounts, palatalized sonorants are followed by epenthetic front vowels as in (6) a + c, non-palatalized sonorants are followed by epenthetic back vowels, as in (6) b + d.

(6)	a.	merʲek	'rust'
	b.	dɔrɔɣ	'fishing line'
	c.	dərʲev	'difficult'
	d.	fɛrak	'anger'

Figure 6. Spectrogram and fundamental frequency plot for a token of a compound whose second element has an epenthetic vowel, [fɛrɛɲɛm], 'nick-name'.

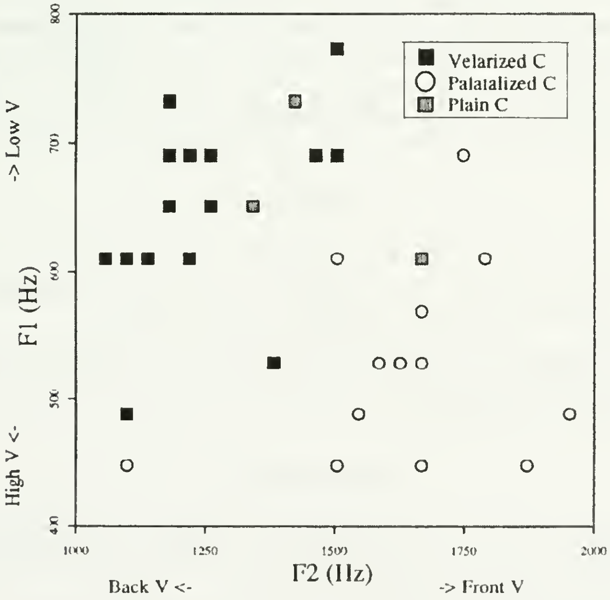


However, some sonorants are phonetically quite audibly velarized -- in traditional terms this is part of the phonological distinction between 'strong' and 'weak' sonorants. In particular, velarized [ɫ] represents the "strong" velarized lateral, and velarized [ʀ] represents the "strong" velarized nasal. (There is no velarized consonant in the rhotic series). Analyses of consonantal effects on the epenthetic vowel presented below assume this three-way distinction between palatalized, velarized, and plain consonants.

Figure 7 plots first and second formant values for epenthetic vowels preceded by palatalized, velarized, and plain (not palatalized/not audibly velarized) sonorants. There is a clear division in the F2 dimension between palatalized vowels (circles) and non-palatalized vowels (squares). The results of a one-way ANOVA with consonant type as an independent variable and F2 as a dependent variable support this observation ($F(2,31) = 17.24$, $p < 0.01$). This result is in general accord with previous accounts.

One surprising aspect of the present results, however, is a slight effect of consonant type on F1 as well as F2. This observation is supported by the results of an ANOVA ($F(2,31) = 13.05$, $p < 0.01$). Previous accounts lead one to expect the consonant type to affect vowels only in the front vs. back (F2) dimension. Another surprising aspect of the present results is an effect on F2 of the distinction between velarized and plain consonants. Previous feature spreading analyses do not predict these results. These results require further investigation, in that they may indicate that a more gradient, phonetically-based model of epenthetic vowel quality may be called for.

Figure 7. Second formant values plotted against first forman values for all epenthetic vowels.



The present corpus, unfortunately, does not have any epenthetic tokens with a high V1; hence analyses of this corpus cannot tell us conclusively whether the observations concerning the connection between the epenthetic vowel and the previous vowel obtain; however, preliminary informal observations of the present corpus suggest that this connection will be confirmed as well with a larger, more well-balanced corpus.

4. Conclusions

This study indicates that the epenthetic vowel in Barra Gaelic is the nucleus of an exceptionally stressed syllable in an otherwise fixed-stress quantity-insensitive system. Furthermore, this prominent syllable bears contrasts which were originally specified on less prominent neighbors. Thus, currently a set of contrasts is distributed across the initial and epenthetic vowel. If we consider the characterization of stress in de Jong 1995 as hyperarticulation of contrasts localized to the syllable, prominent syllables are canonical examples of what Cole & Kisseberth 1995 call "strong anchors" -- that is, locations in which a particular contrast is well supported. Stress, then, acts as a strong anchor and is the target of spreading of contrastive material from less well-supported environments. Cole & Kisseberth 1995 cite Menomini and Coeur d'Alene ATR/RTR harmony and raising in Lena Bable Spanish as other examples of this pattern. One question remains: how do we account for the stress on the epenthetic vowel? Once stress is located there, the collocation of prominence and contrastive features from neighboring vowels is not surprising.

Two conclusions, then, can be drawn from the present study. First, one cannot understand vowel spreading patterns without taking into account the prosodic organization of the utterances involved, especially the stress pattern. And second, phonological analyses which solely account for segmental transcriptions of a language can often be misleading.

NOTES

[1] Data presented here are from Bosch's field notes. All transcriptions are IPA.

[2] An additional way in which the difference is detectable is through the orthography; epenthetic vowels are not marked in the orthography.

[3] While the differences in stressed and unstressed vowel inventory are apparent from Borgstrøm's description of the Barra inventory, Borgstrøm does not explicitly relate these facts to epenthesis.

REFERENCES

BOLINGER, D. 1958. A theory of pitch accent in English, *Word* 7.199-210.

BORGSTRØM, C.H. 1937. The dialect of Barra in the Outer Hebrides. *Norsk Tidsskrift for Sprogvidenskap* 7.71-242.

BOSCH, A. 1991. Phonotactics at the level of the phonological word. University of Chicago, Ph.D. dissertation.

——. 1997. The syllable in Scottish Gaelic dialect studies. *Scottish Gaelic Studies* 18.1-23.

BRUCE, G. 1977. *Swedish Word Accent in a Sentence Perspective*. Lund: Gleerup.

CLEMENTS, G.N. 1986. Syllabification and epenthesis in the Barra dialect of Gaelic. *The Phonological Representation of Suprasegmentals*, ed. by Bogers, et al., 317-36. Dordrecht: Foris.

COLE, J., & C. KISSEBERTH. 1995. Paradoxical strength conditions in harmony systems. *North Eastern Linguistic Society* 25.17-30.

DE JONG, Kenneth. 1995. The supraglottal articulation of prominence in English: Linguistic stress as localized hyperarticulation. *Journal of the Acoustical Society of America* 97.491-504.

FRY, D.B. 1955. Duration and intensity as physical correlates of linguistic stress, *Journal of the Acoustical Society of America* 27.765-8.

——. 1958, Experiments in the perception of stress, *Language and Speech* 1.126-52.

HALLE, Morris. 1995. Feature geometry and feature spreading. *Linguistic Inquiry* 26.1-46.

KENSTOWICZ, Michael, & Charles KISSEBERTH. 1979. *Generative Phonology: Description and Theory*. New York: Academic Press.

NI CHIOSAIN, Maire. 1994. Barra Gaelic vowel copy and (non-) constituent spreading. *West Coast Conference on Formal Linguistics* 13.3-13.

PIERREHUMBERT, J.B. 1980. The phonology and phonetics of English intonation, Massachusetts Institute of Technology, Ph.D. dissertation (available through the Indiana University Linguistics Club, Bloomington, IN.)

—— & M. E. BECKMAN,. 1988. *Japanese Tone Structure*. (Linguistic Inquiry Monograph, 15.) Cambridge: Massachusetts Institute of Technology Press.