Statistical Reanalysis of Munster Irish Stress: M3

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# Abstract

Munster Irish (MI) has been described as presenting a stress pattern that current metrical and non-metrical theories of stress, such as in Hayes (1995); deLacy (2002); deLacy (2004); deLacy (2006), cannot account for: the ternary stress attraction hierarchy of V < /ax/ < V. An acoustic study collected new data in order to reevaluate evidence for the MI stress pattern. Blum (2018)’s statistical analysis of the data from a single speaker of Munster Irish utilized t-tests to determine the significance of the effects of the described stress pattern, syllable position, and frame sentence on various acoustic properties. Using linear mixed effects models, however, provides a more accurate measure of significance and variance while avoiding Type 1 errors (Winter, 2013).

*Keywords:*

Word count:

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# Introduction

The goal of this paper is to provide an acoustic analysis of the word stress system of Munster Irish (MI) via a statistical reanalysis of data from a single native speaker of MI using linear mixed effects models (Winter, 2013). Blum (2018)’s statistical analysis of the speaker’s data utilized t-tests to determine the significance of the described stress pattern, syllable position, and frame sentence for various acoustic properties. Using linear mixed effects models provides a more accurate measure of significance and variance while avoiding Type 1 errors.

Impressionistic descriptions of MI (O’Rahilly 1932, Ó Cúiv 1944, Breatnach 1947, Blankenhorn 1981, Ó Siadhail 1989, Ó Sé 1989, Gussman 2002, Hickey 2014) agree that when a word consists of only short vowels primary stress is on the first syllable. They also agree that if the second syllable contains a long vowel, it will be stressed. In addition, descriptions agree that the syllable [ax] can also attract stress, as in [], but not away from a long vowel (i.e. [CV.Cax], \*[CVCax]); and that coda consonants do not otherwise contribute to stress attraction. The MI stress pattern has thus been described as having a three-way weight distinction between short vowels, /ax/, and long vowels, as shown in () below (Doherty 1991, Bennett 2015).

Blum (2018)’s statstical analysis found that stress did fall on the second vowel in CVCax words and it was confirmed that the first vowel reduces: i.e. /CVCax/ [CCax]. However, in all other word forms, it was argued that stress falls on the initial syllable, even in words with the shape [CVCV]. In addition, it was argued that /a/ never reduces before [x]: i.e. [Cax.Cax], \*[Cax.Cx]. Evidence for stress and resistance to vowel reduction was found in the first formant (F1).

The current paper will reevaluate the same data using linear mixed effects models. Such a reanalysis will simultaneously determine the accuracy of the previous analysis and whether or not the this speaker (M3) produced the described stress pattern.

# Experimental Methods

## Participant

The single subject (M3) was a 74 year old male native speaker of Irish from the Corca Dhuibhne Gaeltacht on the Dingle Peninsula. M3 spoke only Irish until age 10, at which time he had a cleft palate repaired and learned English during his hospital stay. M3 had a minor speech impediment which made it difficult for him to produce coronal stops ([t]s were often fricated) and he has had limited contact with MI in day-to-day life over the past 50 years. While his speech impediment does not likely affect potential correlates of stress, it is possible that the way he speaks is no longer the norm or understood by anyone outside his family. Analyzing data from only one speaker has the possibility of describing an idiolectal difference that is not representative of the stress pattern produced more widely in MI, as it is used daily. However, if the speaker is cognitively intact, his phonological system represents a possible state of the Phonological Module, and so is relevant to evaluating theories of that module’s representational and computational properties. I have reproduced the same experiment in multiple gaeltachtaí of the Munster region of Ireland and in future work I plan to analyze those field recordings for comparison and to determine the stress correlates of MI across speakers and across counties in Munster.

## Stimuli

The target words were existing MI words, initially collected from the online pronunciation database at www.teanglann.ie (2013). The target words were verified by two consulting native speakers of a Connacht dialect and one native speaker of MI. The shapes of the target words allowed comparison of the acoustic properties of [x], [a], [a], and other short and long vowels in both initial and peninitial positions. I assumed that comparing properties of these segments in different environments would be sufficient to identify acoustic properties that differed significantly between these three segments, and thus could be ascribed to phonological metrical prominence.

MI stress has been described to fall mainly on the first or second syllable of a word, so the target list was restricted to roots with two syllables. Wug words were used when stimuli shapes were rare in the www.teanglann.ie (2013) database. Vowel length and syllable shape were controlled so as to test only the forms that are crucial to the described stress pattern. The default stress pattern should be easily detectable in words with two short vowels, as in (Table a). In order to determine the acoustic properties that differentiate stress on long and short vowels in MI, roots with a long vowel in each position of a disyllabic word were also included, as in (Table b). Lastly, the properties of the [ax] syllable were tested in each position adjacent to a short and a long vowel, as in (Table c). The word shapes in (Table ) are also marked with the expected position of stress, based on traditional descriptions.

The vowel and consonant qualities in each position were restricted to include the vowels [i] and [u] (the most common vowels) and crucially [a], which occurs in the [ax] sequence. Some shapes were rare, so a few words with [o] were also included. Vowel identity was included as a factor in the statistical analysis since the vowels vary in inherent duration and inherent F0.

While long vowels are reported to attract stress in MI, coda consonants are not claimed to contribute to syllable weight. For this reason and to restrict the number of shapes tested, no syllables with coda consonants were included, except for the [Cax] syllables in (c). Consonant voicing and manner can affect a preceding vowel’s length (vanSanten, 1992), so medial consonants were limited to the voiceless stops ([p], [t], and [k]) and fricatives ([f], [s], and [x]). Voiceless intervocalic obstruents are both easy to segment and have a smaller effect on preceding vowel duration than do voiced obstruents (vanSanten (1992); p.528-9 and others cited therein). Words with medial fricatives were also included in order to increase the number of real-word stimuli.

There were a total of 69 target words. Seven words of each shape were included, except for CV.Cax words – 13 words were included because this shape is crucial to the issue under contention. The target word list was copied three times and randomized (using Microsoft Excel’s RAND function) to create three sets of stimuli, each with different orders. The three sets of words were combined into a single list. Filler sentences were inserted after every five stimuli.

## Procedure

PsychoPy2 (Pierce, 2009, 2015) was used to generate a presentation of the stimuli such that each target word appeared alone on a computer screen. The subject produced each target word within the two frame sentences in (Table ). The subject saw the sentences and practiced using them with a few words before the experiment began. Target words were produced phrase-medially in order to avoid phrase-final lengthening effects (vanSanten, 1992). Two sentences were used to vary any prosodic (intensity) effects of focus on new vs. old information, following Shih (2016). M3 was recorded in his home and was given the frame sentences to learn. He then began recording with non-target words in order to familiarize himself with the task. He read individual target words written in standard Irish orthography on a computer screen. He then said the word out loud within each of the two frame sentences, and pressed the space bar in order to move on to the next word, continuing at his own pace.

Recordings were made using a head-mounted AKG C420 condenser microphone in order to maintain a constant distance between the mouth and the microphone, with the goal of eliminating amplitude variation due to head movement. The microphone was connected to a Marantz PMD670 solid state recorder, which recorded using 44.1 kHz sample rate and 16 bit quantization rate in mono. The data was saved as a RIFF (.wav) file to ensure that no information was lost due to a lossy compression codec. The participant’s recordings were saved in a coded file, which was then segmented manually using Praat (Boersma & Weenink, 2013).

Segmentation was done by hand using primarily the waveform and secondarily F2 to determine where segments began and ended. Vowels were taken to begin at the zero-crossing of the first upswing of the first non-deformed period and ended at the zero-crossing of the last downswing of the last non-deformed period. If the boundary was unclear based on the waveform, vowel boundaries were determined by the presence of a robust F2 in the spectrogram, as long as there was a robust F1 underneath. Fricatives were taken to begin at the zero-crossing of the first downswing of the last non-deformed period of the preceding vowel and ended at the zero-crossing of the first upswing of the first non-deformed period of the following vowel. Fricatives boundaries were confirmed by the onset and offset of noise in the spectrogram.

# Statistical Analysis

## Previous Findings

Blum (2018)’s statistical analysis utilized Student’s t-tests in Microsoft Excel to determine where there was variation within the M3 data. The t-tests were used to determine which acoustic properties correlate with word-level stress. The previous analysis assumed a restricted p-value threshold of 0.01 rather than the more generous standard of 0.05 in order to adjust for family-wise error and avoid capitalizing on chance, but the possibility of committing a Type 1 error remained due to the high number of tests run on the single dataset.

Blum (2018)’s t-test analysis found that stress did fall on the second vowel, but only in CVCax words and it was confirmed that the first vowel reduces: i.e. /CVCax/ [CCax]. In all other word forms, it was argued that stress falls on the initial syllable, even in words with the shape [CVCV]. In addition, it was argued that /a/ never reduces before [x]: i.e. [Cax.Cax], \*[Cax.Cx]. Evidence for stress and resistance to vowel reduction was found in the first formant (F1). The vowels [a] and [] were found to significantly differ in height, but their distribution was not indicative of the traditionally described stress pattern. For example, an initial short [a] adjacent to a long vowel did not reduce, but adjacent to an [ax] syllable it did. Crucially, F1 was also claimed to indicate that the vowel in an [ax] syllable does not reduce to generate [x].

## Reanalysis Methods

The current analysis of M3’s data uses linear mixed effects models in R (R Core Team, 2016) via the lmer function of the lme4 package (Bates, Mächler, Bolker, & Walker, 2015). Separate models were built for each of two vowels ([a] and []) and each of three acoustic properties (vowel duration, F1, and F2). Data was organized in long format such that each variable occupied a separate column and each row contained a single vowel’s data. Rows were labeled with the word, syllable shape, and vowel (as it was segmented) in separate columns in that order. To the right of the vowel label were the continuous variables duration, F1, F2, F3 in order. Each vowel was also coded for the categorical variables frame sentence (1 or 2), syllable position (1 or 2), and stress (0 or 1 according to the descriptions).

# Results

The lmer() function was used to separately model each of the continous dependent variables (duration, F1, and F2) as a function of the three fixed effects (frame, syllable, and stress). In addition, the mixed effects models encoded a random effect of word, which was labeled by the file name. Statistical significance was assessed using hierarchical partitioning of variance via nested model comparisons. Models were compared using the anova() function. Visual inspection of residual plots revealed both normal distribution and homoskedasticity.

## Short [a] vowels

Short [a] vowels include all vowels marked as [a] during segmentation. These include both those in /ax/ syllables and those that are not. Whether or not they were marked as stressed (1), depends upon the other vowel present in the word. So [a] vowels, whether or not they are in an /ax/ syllable, would be marked as unstressed (0) if the other vowel in the word is long, for example.

### Duration

Stress and syllable position were shown to have a significant effect on the duration of [a] vowels (p < 0.05), but frame sentence did not. There was a main effect of stress on duration (2(1)=0.97, p=3.255e-01), which lowered it by 6.796 ms 6.9 standard errors. There was a larger main effect of syllable position on duration (2(1)=26.443, p=2.714e-07), which increased it by 44.707 ms 8.167 standard errors. No effect of frame sentence was found.

### F1

Stress was shown to have a significant effect on the F1 of [a] vowels, but neither syllable position nor frame sentence did. There was a main effect of stress on F1 (2(1)=27.966, p=1.235e-07), which increased it by 73.06 hz 12.94 standard errors. The effect of syllable position on F1 was shown not to be significant (2(1)=0.2704, p=0.6031). No effect of frame sentence was found.

### F2

No categorical factors were shown to have a significant effect on F2. The effects of both stress (2(1)=1.337, p=0.25) and syllable position (2(1)=2.89, p=0.089) were found not to be significant. No effect of frame sentence was found.

## [] Vowels

[] vowels include all vowels marked as [] during segmentation. These include both [] in /ax/ syllables and those that are not. There are stressed [] vowels in the two CC words, which were also extremely common words—[] ‘(cooking) pot’ and [] ‘(drinking) cup’. According to Green (1996:4) it is possible that the schwas in stressed syllables are underlying and not the result of vowel reduction.

### Duration

All three categorical predictors were shown to have a significant effect on duration. There was a main effect of stress (2(1)=29.827, p=4.723e-08), which decreased duration by 32.226 ms 5.629 standard errors. There was a main effect of syllable position (2(1)=48.692, p=2.996e-12), which increased duration by 38.668 ms 5.318 standard errors. And there was a main effect of frame sentence (2(1)=15.954, p=6.489e-05), which increased duration by 11.850 ms 2.887 standard errors.

### F1

All three categorical predictors were also shown to have a significant effect on the F1 of . There was a main effect of stress (2(1)=9.5367, p=0.002014), lowered F1 by 50.712 ms 15.837 standard errors. There was a main effect of syllable position (2(1)=6.4637, p=0.01101), which increased F1 by 40.34 ms 15.50 standard errors. And there was a main effect of frame sentence (2(1)=40.431, p=2.036e-10), which decreased F1 by 62.251 ms 9.216 standard errors.

### F2

Only frame sentence significantly affected the F2 of vowels. The effect of stress on F2 was shown not to be significant (2(1)=0.4965, p=0.481). The effect of syllable position was also shown not to be significant (2(1)=0.0069, p=0.9338). There was, however, a main effect of frame sentence (2(1)=22.432, p=2.177e-06), which decreased F2 by 97.43 ms 19.88 standard errors

# Discussion

The described stress pattern was shown to be a significant predictor of duration and F1 for both short [a] and [] vowels. Duration was decreased and F1 was increased based on whether or not [a] and [] occured in a syllable traditionally described as stressed. Duration of [a] and duration and F1 of [] were all increased by syllable position. F2 was not predicted by any of the categorical factors for [a], but was predicted by frame sentence for [] vowels. This result is in line with Blum (2018)’s results, which suggested that F1 was the only significant correlate of stress in MI.

Duration increased only based on syllable position. The plot below, shows that [a] vowels were generally lengthened in the second syllable, which could also be a result of word- or phrase-final lengthening effects (vanSanten, 1992).

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