The value of Irish schwa: An acoustic analysis of epenthetic vowels

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This study was conducted in an effort to learn more about the phonology of the Irish language. The research is intended to be a phonetic analysis of one of the phonological processes characteristic to Celtic languages. The present study examines the extent to which schwa epenthesis in Irish acts as a neutralization process. A list of 30 Irish words acting as near-minimal pairs was compiled for this study. Vowel environment and syllable count matched across pairs, and only the vowel itself differed in whether it was epenthetic or underlying. Six native-Irish speakers were recruited for this experiment representing all three major dialects of the language: three speakers from Cork (Munster), two speakers from Donegal (Ulster), one speaker from Connemara (Connacht). Participants read from the word list, reading each word twice. Acoustic analysis focused on two measurements: vowel duration and formant frequencies. The formants for each vowel type are comparable, but the difference in duration is significant, indicating that Irish schwa epenthesis is an incomplete neutralization process. While schwa epenthesis has been reported to create an identical phonological form to that of the underlying schwa, the significant difference in vowel duration indicates a residual contrast of the original underlying forms.

Keywords: epenthesis, neutralization, Irish, vowel duration

1. Introduction

Epenthesis is a recognized neutralization process found in a variety of world languages including Arabic, Welsh, Mono, and Dutch (Hall, 2006, 2011). The insertion of an underlyingly absent vowel neutralizes pre-existing contrasts between different lexical items. Evidence of this process is visible in Irish, and most obviously in the orthography. Words like anam ([anəm] "soul"), become minimal pairs with words like *ainm* ([anəm] "name"), pronounced identically and distinguished only by the underlying value of schwa.

Epenthesis is a phonological process seen in a variety of Celtic languages. However, little literature exists that pertains to both the acoustic value of these vowels and Irish in particular. The goal of the present study is to identify whether or not there exists a difference between underlying and epenthetic schwa in Irish.

2. Irish and epenthesis

2.1. Irish language status. Irish is the first national language of the Republic of Ireland, despite only 1% of the Irish population relying solely on its use. There are only a few pockets in the western parts of the country where Irish is spoken on a daily basis; these areas are called *Gaeltachts* and are common in Counties Donegal, Galway, and Kerry (Hickey, 2014). Irish shares a unique relationship with English, for while Irish is the country's first national language, English is the primary language used in everyday conversation. Throughout the country, Irish and English place names are both listed on road signs, public offices, and official documents (Hickey, 2014). Today, Irish is taught in schools until the equivalent of high school, and even then, the subject is not included in final examinations. The Irish language is a compulsory part of the curriculum in all government-funded schools in the Republic of Ireland (Ó'Murchú, 2001). In summary,

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the people of Ireland have a core understanding of basic Irish, but the language is rarely used on a regular basis.

2.2. Epenthesis in Irish. Epenthesis is the phonological process of vowel insertion. In most cases, such a process is used to break up phonologically inadmissible clusters, and in Irish, schwa [ə] is the only epenthetic vowel. Hickey makes a number of general statements about the epenthetic vowel in Irish. Firstly, an epenthetic vowel never carries any lexical information nor does it indicate grammatical category. Additionally, an epenthetic vowel is never stressed (Hickey, 2014).

gorm	"blue"	/goɹm/	[goɹə̲m]
ainm	"name"	/anə̲m/	[anə̲m]
seilg	"hunt"	/ʃɛlə̲g/	[ʃɛlə̲g]

Table 1: Words with epenthetic vowels

In essence, epenthetic schwa is inserted between two consonants where C1 is sonorant (Carnie, 1994). Furthermore, the consonants must be non-homorganic in their place of articulation. The first consonant in the sequence is always a sonorant, but the nature of the second is not obvious. It appears that the second consonant is at least as sonorant as a voiced obstruent, and is never a voiceless stop. Typologically, the more congruent the two consonants are in sonority, the less likely the phonology is to allow such a cluster; in general, languages disprefer rising or flat sonority sequences in their codas (Gordon, 2016). However, according to Carnie (1994), epenthesis is likely to be triggered in Irish where there is a minimal difference in sonority between adjacent segments. Running with Carnie's conclusion, the farther apart the consonants in the sequence fall on the sonority scale, the more acceptable they are and the less likely epenthesis is to occur. Hickey (2014) goes on to discuss an explicit cut-off point in the sonority hierarchy in Irish between the voiced and voiceless plosives that trigger epenthesis:

a)	sonorants and sonorants
b)	sonorants and voiced fricatives
c)	sonorants and voiceless fricatives
d)	sonorants and voiced stops
e)	[sonorants and voiceless stops]

Table 2: Preferential environments for epenthesis

There is another type of epenthesis that has been identified in Irish, known as "secondary epenthesis." This kind of epenthesis is an optional process that normally occurs in onset clusters (Carnie, 1994). According to Carnie, secondary epenthesis occurs in the following morphological contexts: within morphemes, between compounds, between affixes and stems, at word edges, before inflectional suffixers, in borrowed words, and in the middle of words (Carnie, 1994). Given the different phonological and morphological nature of secondary epenthesis, the current study only focuses on the obligatory primary epenthesis that occurs within monomorphemic words.

This phenomenon is so prevalent in Irish, that evidence of it has even surfaced in Irish English. English words like film [fɪlm] and farm [faɹm] surface as [fɪləm] and [faɹəm] in Irish English dialects (Sell, 2012). Irish English has been studied in its own right, and the epenthesis so characteristic to Irish plays a role in the English dialect spoken in Ireland. Overall, epenthesis is a very recognizable process within Irish phonology and, in fact, within a number of other Celtic languages.

2.3. Literature review.

2.3.1 Phonological invisibility. The motivation for this study stems most directly from research conducted on a similar language with a similar phenomenon. Hammond et al. (2014) asked if epenthetic vowels in Scottish Gaelic were treated the same as their underlying counterparts. Scottish Gaelic, like Irish, inserts neutral schwa in certain environments:

aran	/aran/	[ar.an]	"bread"
arm	/arm/	[a.r̪a̪m]	"army"
seanair	/ʃɛnɛɪ/	[ʃɛn.ɛɪ]	"grandfather"
seanmhair	/ʃɛnvɛɪ/	[ʃɛ.nɛ̪v.ɛɪ]	"grandmother"

Table 3: Scottish Gaelic words with inserted vowels

Earlier arguments had been made that the epenthetic schwa was excrescent, that it does not affect syllable counts or other facets of the phonology of the word. Hall (2006) claimed that inserted vowels in Scottish Gaelic were phonologically invisible. The characteristics of excrescent vowels include: the vowel is likely optional; the vowel is either schwa or a copy of a nearby vowel; if it is a copy, it copies over sonorant or guttural consonants, "guttural" referring to velar, uvular, or pharyngeal consonants; the vowel occurs in heterorganic clusters; the vowel does not repair illicit structures (Hall, 2006). The inserted vowels in Scottish Gaelic exhibit many of these properties. In regard to Hammond et al.'s (2014) research, the argument of excrescence claimed that this extra vowel did not add any kind of additional syllable weight to the word. The Hammond et al. (2014) study sought to determine whether the inserted vowel was truly phonologically invisible as had been previously hypothesized. Hammond et al. (2014) conducted a variety of experiments including word identification tasks, nonsense word tasks involving spelling and vowel interpretation, and knocking for syllable beat tasks. Looking at the question of excrescence, the syllable counting tasks were revealing. Subjects were prompted with an English word or phrase and were instructed to give the Scottish Gaelic equivalent. They were then asked to count the number of syllables in the word they offered. Subjects in Hammond et al.'s (2014) study had a different syllable count for words with and without inserted vowels.

The results from Hammond et al.'s (2014) experiments indicate that native speakers of Scottish Gaelic do assign some value to epenthetic schwa, but that it is still less than their underlying counterparts. Participants preferred to count the inserted schwa as contributing half a syllable rather than none at all and responded to the prompt with responses like "one and a half syllables." Native speakers were generally able to distinguish between the two types of vowels even when they were removed from context. Hammond et al. (2014) concluded that the inserted vowels in Scottish Gaelic are not equivalent to underlying vowels, but they are, nevertheless, phonologically recognized.

2.3.2 Incomplete neutralization. By inserting a vowel into a word that underlyingly does not have that vowel (and in the case of Irish, the orthography doesn't recognize it either), the distinction between lexical items that have and do not have that vowel underlyingly is wiped out. On the surface, these become words that are pronounced the same way despite their distinct meanings, and sentence context becomes one of the few cues that can help identify the word meaning.

However, an increasing number of phonetic studies have found that phonological processes that were reported to be neutralizing, in fact, leave a residual difference between the two underlying forms. This phenomenon is referred to as incomplete neutralization. For instance, studies conducted by Fourakis and Iverson (1984), Port and Crawford (1989), and Charles-Luce (1985) on German final devoicing found significant differences in the acoustics surrounding what should have been the neutralized environment. By measuring the vowel duration of the preceding vowel and the closure duration of the final consonant, these authors were able to identify an incomplete neutralization process (Zhang, 2017). Final devoicing is also recognized as an incomplete neutralization process in Russian. Using 34 word pairs contrasting in the underlying voicing of the final obstruent, Dmitrieva et al. (2010) analysed four measures (duration of the preceding vowel, duration of the final obstruent, duration of voicing into closure, duration of release of final stop). Their study revealed that speakers of Russian, native and learner, produce the two types of words differently, subconsciously recognizing that their underlying forms differ.

In Scottish Gaelic, schwa epenthesis should have wiped out the difference in syllable count between words like aran [ar.an] and arm [ar.am]. Although the main goal of Hammond et al's (2014) experiment was to determine whether the epenthetic vowel was phonologically visible at all, the fact that they found a difference in syllable count between the two types of words indicates that epenthesis in Scottish Gaelic is

an example of incomplete neutralization. Had the ∅ ∼ schwa distinction truly been lost, the syllable count of the word with the epenthetic vowel would have been identical to that of the one with the underlying schwa. But the contrast is still realized in the numerical values of the syllable count; words like arm [ar.am] that should have had one syllable were assigned an extra syllable 59% of the time (Hammond et al., 2014).

Looking at Irish epenthetic vowels, should there be a significant difference in the duration and formant values of epenthetic and underlying vowels, the Irish process of epenthesis should be considered an example of incomplete neutralization as well. The present study diverges from previous literature in that it focuses on a phonetic analysis of the sounds in question.

3. Research proposal

3.1. Research hypothesis. There is a significant difference between the vowel duration of epenthetic and underlying schwa in Irish. Additional differences between the two vowel types can be gleaned from formant frequencies. These two hypotheses involving context-independent differences differ from the final hypothesis that epenthetic vowels in environments where the sonority distinction between the two consonants is less severe should be longer as their presence is required to break up that dispreferred coda cluster.

The aim of this research is to establish whether there is any inherent acoustic difference between epenthetic and underlying vowels in Irish. Such a differentiation in acoustics would classify Irish epenthesis as an incomplete neutralization process.

4. Methods

4.1. Participants. All of the participants recruited for this experiment were native speakers of Irish, and to varying degrees, they instruct others in its use. Codes were used in place of participant names: the first letter refers to the dialect of the speaker and the second to their gender.

Participant	Location	Dialect	Profession	Recruited via
M1-M	Cork	Munster	Professor of Modern Irish, Irish university	Email
M2-M	Cork	Munster	Grammar school teacher	Email, family friend
M3-F	Cork	Munster	Grammar school teacher	Email, Facebook, family friend
U1-M	Donegal	Ulster	Instructor with Irish adult language school	Email
U2-F	Donegal	Ulster	Fulbright Teaching Assistant, Irish College	Email
C1-F	Connemara	Connacht	Celtic Studies Professor, US university	Email

Table 4: Participant background information

Recruiting participants for this study proved challenging as email was the primary means of communication. Requests for advice and resources were sent to a myriad of educational institutions, ranging from universities to summer language retreats; the individuals above responded.

4.2. Stimuli. A list of 15 Irish near-minimal pairs was constructed with the aid of an online Irish dictionary. Near-minimal pairs contained similar environments; emphasis was placed on the similarity of the surrounding consonants and, on occasion, on the quality of the preceding vowel.[1] Stimuli contrasted in the underlying presence of schwa. 15 words contained an underlying schwa, recognized by the orthography; 15 words contained an epenthetic schwa that was not recognized by the orthography.

[1]The initial plan was to compile a word list and then insert the target words into carrier sentences to elicit less rehearsed speech. The carrier sentences proved problematic given Irish's VSO structure, genitive case-markings, and the fact that few Irish experts were at hand to confirm the proposed structures.

Underlying			Epenthetic		
/ɹb/			/ɹb/		
parabal	[paɹəbl]	“parable”	carball	[kaɹə̲bəl]	“gum”
/ɹm/			/ɹm/		
urraim	[oɹəm]	“deference”	orm	[oɹə̲m]	“on me”
cothrom	[kɔɹɪm]	“balance”	gorm	[gɔɹə̲m]	“blue”
éirim	[eɹɪm]	“gist”	feirm	[fɛɹɪ̲m]	“farm”
/ɹn/			/ɹn/		
torann	[taɹən]	“sound”	carn	[kaɹə̲n]	“heap”
fearann	[fæɹən]	“grounds”	corn	[kɔɹə̲n]	“trophy”
/ɹg/			/ɹg/		
léirigh	[leɹɪg]	“manifest”	dearg	[daɹə̲g]	“red”
cóirigh	[kɔɹɪg]	“prepare”	lorg	[lɔɹə̲g]	“invite”
/lm/			/lm/		
foghlaim	[faulɪm]	“glean”	colm	[kʌlə̲m]	“dove”
/lv/			/lv/		
talamh	[taləv]	“ground”	sealbh	[ʃɛlə̲v]	“possession”
ullamh	[oləv]	“ready”	balbh	[bolə̲v]	“mute”
éileamh	[eləv]	“demand”	dealbh	[dælə̲v]	“poor”
/lg/			/lg/		
reilig	[ɹɛlɪg]	“graveyard”	seilg	[ʃɛlə̲g]	“hunt”
/nm/			/nm/		
anam	[anəm]	“soul”	ainm	[anə̲m]	“name”
/nv/			/nv/		
gaineamh	[ganəv]	“sand”	banbh	[banə̲v]	“piglet”

Table 5: Example?

The majority of the words used as stimuli were monomorphemic (*orm*, “on me” being the only exception) and, on the surface, bisyllabic (*parabal* “parable” and *carball* “gum” being the only exceptions). Schwa was always realized in the second syllable of the word, whether it was epenthetic or underlying, and stress fell on the first syllable. The main focus of the study was the CVC/CV̲C segments in the second syllable of the near-minimal pairs, where V represents underlying schwa and V̲ represents epenthetic schwa.

4.3. Procedure. Participants were asked to read each word from the list twice before proceeding to the next. This instruction allowed for subjects to become comfortable with the target word and to give the researcher a choice in data selection, although the second utterance of each word was selected from each participant for consistency across samples.

Participants were left to their own preferences in how they recorded their speech, and a myriad of file types were submitted (ie. MP3, M4a, wma, .3gp). Each file was converted to a .wav file for analysis in Praat, but because of the long-distance and virtual nature of the researcher-participant interaction, control of the recording environment and full-knowledge of recording software was not available. Nevertheless, the data received was clear and organized.

Having converted the original sound files to .wav files, the second utterance of each word was identified and measured individually in Praat. Because of the sonorant nature of the consonant preceding the vowel,

special care was taken in measuring the duration of the vowel. The spectrograms were used to identify the vowels, and the beginning and end points of the vowel were located by sudden changes of the formant structure. All the vowel durations in this study were measured this way consistently. F1 and F2 were the formant frequencies measured in this study. Formant measurements were taken from the middle of the vowel utterance.

5. Results

All but one of the participants sent back recordings that contained the requested repetition of each word. The data from the last participant (C1-F) was taken from a recording that only had one utterance of each word. The duration patterns seen in her speech were vastly different from those observed in the other participants; the careful reading of the word list may have contributed to her slower speech and the difference in underlying pattern. Due to this difference between subject data, results from C1-F are included separately but still acknowledged in the analysis.

5.1. Vowel duration. A repeated measures ANOVA was run in SPSS to compile the data presented below:

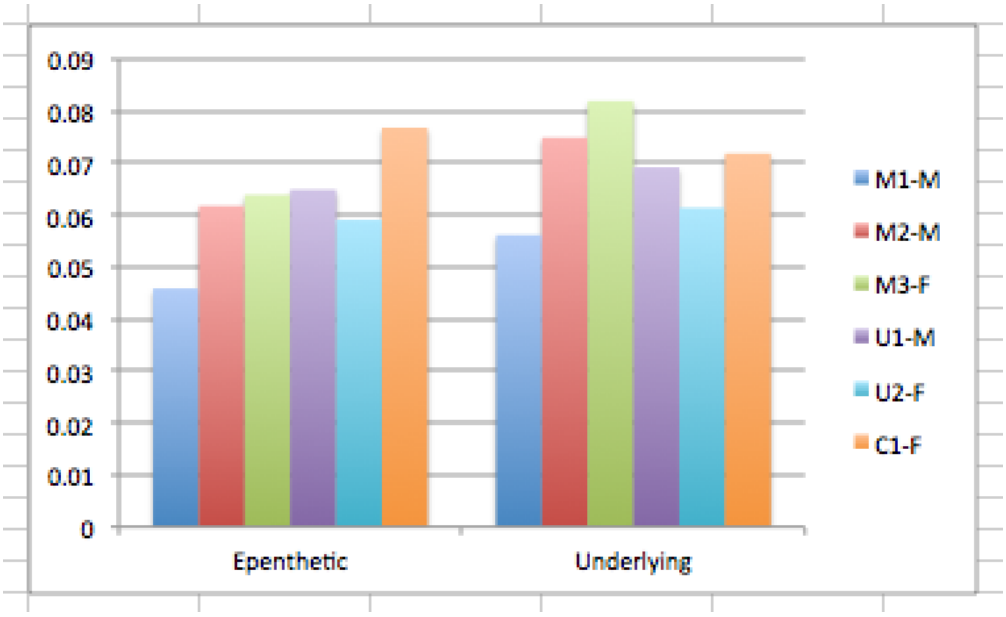

Figure 1: Vowel duration in epenthetic and underlying cases

Excluding the data from C1-F, results indicate that there is a significant difference in the duration of underlying and epenthetic vowels. Given the first five speakers, epenthetic vowels have an average duration of 0.059 seconds whereas underlying vowels average 0.069 seconds. Epenthetic vowels are nearly 10 milliseconds shorter than their underlying counterparts; while this difference is likely unnoticeable to speakers, it is enough to note that there is an inherent acoustic difference between the two types of vowels. Results of the ANOVA were significant at $p < 0.029$. Considering the data with results from C1-F, there is no significant effect of the underlying vs. epenthetic variable and the null hypothesis is more appropriate ($p = 0.086$). C1-F, the one participant who read each word only once, was the only participant whose epenthetic vowels were not, on average, shorter than her underlying ones. This could be, in part, due to the fact that she only read each word once; her careful reading may have affected the rate of her speech and slowed it down in comparison to the other participants. After including the last set of data the average duration for epenthetic vowels jumped to 0.062 seconds and the average duration for underlying vowels went to 0.069, a difference too small to be considered significant.

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Epenthesis	Sphericity Assumed	.000	1	.000	11.211	.029
	Greenhouse-Geisser	.000	1.000	.000	11.211	.029
	Huynh-Feldt	.000	1.000	.000	11.211	.029
	Lower-bound	.000	1.000	.000	11.211	.029
Error(Epenthesis)	Sphericity Assumed	8.269E-5	4	2.067E-5		
	Greenhouse-Geisser	8.269E-5	4.000	2.067E-5		
	Huynh-Feldt	8.269E-5	4.000	2.067E-5		
	Lower-bound	8.269E-5	4.000	2.067E-5		

Table 6: Results of repeated measures ANOVA on vowel duration

Figure 2: Overall duration differences with and without data from C1-F

5.2. Formant frequencies. The formant frequency measurements were not affected by adding C1-F's data to the mix. F1 and F2 measurements for epenthetic vowels averaged at 550 Hz and 1680 Hz, respectively; underlying vowels averaged an F1 at 535 Hz and an F2 at 1729 Hz.

F1 and F2 averages were analyzed in SPSS using a repeated measures ANOVA. The *p* values for F1 ($p = 0.39$) and F2 ($p = 0.23$) did not indicate a significant difference between the two vowel types. It can be concluded that the formant frequencies of both epenthetic and Irish schwa are not significantly different from one another.

5.3. Sonority of environments. Further analysis was conducted in relation to the environments in which schwa was inserted. This comparison was motivated by an interest in determining if the duration of the epenthetic vowel differed depending on the environment (i.e. Would it be longer if the sonority of the two consonants was more similar?) Considering Carnie's previous mention of the sonority scale, each epenthetic environment was categorized according to consonant type and the averages of each speaker were compared.

No pattern was discovered that aligned with the notion of the sonority hierarchy and disliked coda sequences. Had the research hypothesis been correct, epenthetic vowels in sequences like (liquid + nasal) or (nasal + nasal) should have elicited longer durations given their proximity in the sonority hierarchy. While the pattern given this sample does not align with Carnie's hypothesis, the sample size was not truly adequate to confirm this trend.

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
epenthetic	Sphericity Assumed	.000	1	.000	4.535	.086
	Greenhouse-Geisser	.000	1.000	.000	4.535	.086
	Huynh-Feldt	.000	1.000	.000	4.535	.086
	Lower-bound	.000	1.000	.000	4.535	.086
Error(epenthetic)	Sphericity Assumed	.000	5	3.426E-5		
	Greenhouse-Geisser	.000	5.000	3.426E-5		
	Huynh-Feldt	.000	5.000	3.426E-5		
	Lower-bound	.000	5.000	3.426E-5		

Table 7: Results of repeated measures ANOVA on vowel duration excluding C1-F data

Tests of Within-Subjects Effects

Measure: Epenthetic

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
factor1	Sphericity Assumed	313.892	1	313.892	.869	.394
	Greenhouse-Geisser	313.892	1.000	313.892	.869	.394
	Huynh-Feldt	313.892	1.000	313.892	.869	.394
	Lower-bound	313.892	1.000	313.892	.869	.394
Error(factor1)	Sphericity Assumed	1806.416	5	361.283		
	Greenhouse-Geisser	1806.416	5.000	361.283		
	Huynh-Feldt	1806.416	5.000	361.283		
	Lower-bound	1806.416	5.000	361.283		

Table 8: Results of repeated measures ANOVA on F1

6. Discussion and conclusion

The present study examined the acoustic characteristics of epenthetic vowels in Irish as compared to their underlying counterparts. Six native speakers of Irish were recruited for the experiment, all of them with careers related to teaching, a career that requires a standard knowledge of the Irish language. In order to compare the two vowel types in question, two measurements were taken: vowel duration and formant frequencies. The research hypothesis predicts a difference between the two types of vowels.

Results indicate that there is a significant acoustic difference in the duration of the vowels. Perhaps a residual effect left over from its underlying form, epenthetic vowels are generally shorter in duration (approximately 10 milliseconds) than underlying vowels. These results indicate that Irish epenthesis is an incomplete neutralization process. The process that should have eliminated the contrast between words fails to do so because the contrast leaves a residue on the surface forms of the words. In this case, the underlying absence of a vowel makes the inserted schwa shorter than one that is underlyingly present. Looking at the other measurements taken, formant frequencies were consistent across vowel types. This confirms that the epenthetic vowel is normally realized as neutral schwa.

Despite these discoveries, there were inherent setbacks to the set-up and actualization of this experiment. The small number of participants is a hindrance to the generalizability of the results. The difficulty in accessing native Irish speakers and experts on the language proved challenging. This was also seen in

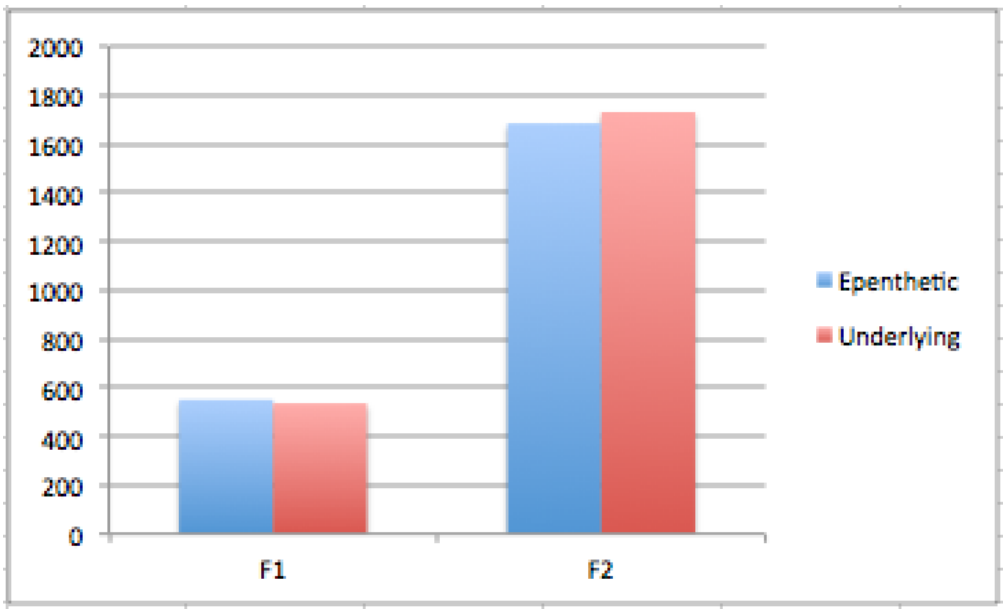

Figure 3: Formant frequencies of epenthetic and underlying vowels

the reliance on a word list rather than the use of meaningful Irish sentences. The limitations of words lists include: the plain reliance on orthography where the speaker's production might be swayed on how the word is spelled; the repetitive nature of the word list leads to careful reading, which is more likely to exaggerate any difference related to orthography. Future studies should take advantage of the opportunity to recruit more native Irish participants and to move away from strict word list use.

Questions regarding the value of the epenthetic vowel, its perception, and its initial motivation arose from this study. Having to transcribe recordings from an online Irish dictionary, the transcriptions seen in the original list of words with epenthetic vowels were based solely on one recording available via the website. Nevertheless, it was thought that in some cases [ɪ] was more appropriate than [ə]. The fact that [ə] seemed to surface as [ɪ] calls into question the phonological status of the epenthetic vowel and the process through which each of its forms is realized. Vowel harmony could play a role in determining which vowel is preferable given the features of the vowel in the first syllable, but further analyses are necessary before any real conclusion can be reached. Another research opportunity extends in the direction of speaker perception. Even though the difference in duration is statistically significant, it may be imperceptible to native speakers. Nevertheless, epenthetic vowels have a weight and affect the language's phonology. A follow-up experiment related to Hammond et al.'s (2014) work with Scottish Gaelic is feasible now that an acoustic difference in the vowels can be accounted for.

Additionally, the notion that this vowel is epenthetic is motivated primarily through orthographic representation and historical linguistics (Jaskula, 2006). Epenthetic vowels are not represented in the orthography, and it is understood that that is the indication of their not existing in the underlying representation. In short, cues from the orthography are the driving force behind the classification of this vowel, and while the author did find one example of phonological alternation (hunt = seilg [ʃɛlə̯g], hunter = sealgaire [ʃɛlgəɾə]), a more developed list and further research should be conducted in order to better understand how these words behave with and without this inserted vowel.

Results of this study indicate that although native speakers may not recognize it, there is an acoustic difference between Irish epenthetic and underlying schwa. This evidence of incomplete neutralization adds to the discussion on theoretical motivations of such processes and opens up doors for future study of the Celtic languages.

Tests of Within-Subjects Effects

Measure: Epenthetic

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
factor1	Sphericity Assumed	6445.850	1	6445.850	1.857	.231
	Greenhouse-Geisser	6445.850	1.000	6445.850	1.857	.231
	Huynh-Feldt	6445.850	1.000	6445.850	1.857	.231
	Lower-bound	6445.850	1.000	6445.850	1.857	.231
Error(factor1)	Sphericity Assumed	17354.877	5	3470.975		
	Greenhouse-Geisser	17354.877	5.000	3470.975		
	Huynh-Feldt	17354.877	5.000	3470.975		
	Lower-bound	17354.877	5.000	3470.975		

Table 9: Results of repeated measures ANOVA on F2

Word	Environment	Sonority Sequence	Mean Dur. (s)
balbh	ləv	liquid + fricative	0.096
dealbh	ləv	liquid + fricative	0.069
seilbh	ləv	liquid + fricative	0.076
colm	ləm	liquid + nasal	0.057
feirm	ɹəm	liquid + nasal	0.065
gorm	ɹəm	liquid + nasal	0.067
orm	ɹəm	liquid + nasal	0.058
carn	ɹən	liquid + nasal	0.033
corn	ɹən	liquid + nasal	0.047
seilg	ləg	liquid + plosive	0.093
carball	ɹəb	liquid + plosive	0.044
dearg	ɹəg	liquid + plosive	0.068
lorg	ɹəg	liquid + plosive	0.051
leanbh	nəv	nasal + fricative	0.074
ainm	nəm	nasal + nasal	0.060

Table 10

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References

Carnie, A. (1994). Whence sonority? Evidence from epenthesis in Modern Irish. *Papers on Phonology and Morphology*.

Charles-Luce, J. (1985). Word-final devoicing in German and the effects of phonetic and sentential contexts. *The Journal of the Acoustical Society of America, 77*(S1), S85.

Dmitrieva, O., Jongman, A., & Sereno, J. (2010). Phonological neutralization by native and non-native speakers: The case of Russian final devoicing. *Journal of Phonetics, 38*(3), 483–92.

Fourakis, M., & Iverson, G. K. (1984). On the 'incomplete neutralization' of German final obstruents. *Phonetica, 41*(3), 140–149.

Sonority Sequence	Average
liquid + nasal	0.055
liquid + fricative	0.080
liquid + plosive	0.064
nasal + fricative	0.074
nasal + nasal	0.060

Table 11

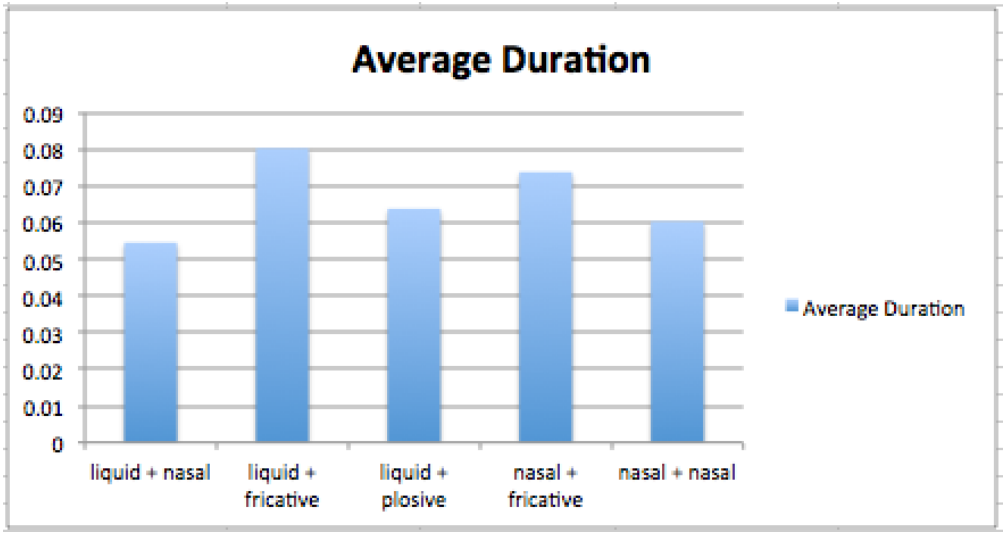

Figure 4

Gordon, M. (2016). *Phonological typology*. Oxford: Oxford University Press.

Hall, N. (2006). Cross-linguistic patterns of vowel intrusion. *Phonology, 23*(3), 387–429.

Hall, N. (2011). Vowel epenthesis. In *The Blackwell Companion to Phonology* (pp. 1576–1596) . Oxford: Wiley-Blackwell.

Hammond, M., Warner, N., Davis, A., Carnie, A., Archangeli, D., & Fisher, M. (2014). Vowel insertion in Scottish Gaelic. *Phonology, 31*(1), 123–53.

Hickey, R. (2014) *The sound structure of modern Irish*. Berlin: De Gruyter Mouton.

Jaskula, K. (2006). *Ancient sound changes and Old Irish phonology.* Lublin.

Ó'Murchú, H. (2001). The Irish language in education in the Republic of Ireland. *Mercator-Education: European Network for Regional or Minority Languages and Education*.

Port, R., & Crawford, P. (1989). Incomplete neutralization and pragmatics in German. *Journal of phonetics, 17*, 257–282.

Sell, K. (2012). [ˈfɪləm] and [ˈfarəm]? Sociolinguistic findings on schwa epenthesis in Galway English. In Migge, B., & Ní Chiosáin, M. (Eds.), *Varieties of English around the world*. Amsterdam/Philadelphia: John Benjamins Publishing Company.

Zhang, J. (2017). The consequences of incomplete neutralization [Lecture]. *Linguistics 910*. University of Kansas, Lawrence, KS.