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An Optimality Theory Approach to Initial Consonant Mutation in Modern Irish

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Declaration

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Anna Lawless
April 2018

Abstract

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Initial consonant mutation is a well-known characteristic of the Celtic languages, but it is still not fully understood. It consists of the systematic phonological alternation of word-initial consonants in certain morphosyntactically defined environments. Because the phenomenon exists at the interface of phonology, morphology and syntax, it poses a problem to most traditional theories of grammar.

This dissertation proposes a novel approach to initial consonant mutation in Modern Irish, within the framework of Optimality Theory. Mutation is triggered by the presence of "mutation morphemes", which consist of sets of floating phonological features, and are assumed to be fundamentally associated with the target word. A set of language-specific morphosyntactic constraints determine whether or not mutations are realised in the surface form of the word. By evaluating phonological and morphosyntactic constraints simultaneously, most of the irregularities in the Irish data can be accounted for. Furthermore, this analysis yields valuable insights into the theoretical system underpinning the Irish mutations. In particular, it accounts for the restriction of mutation to content words, and can also explain why the exact same mutations appear in such a diverse range of contexts.

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1 Introduction

Initial consonant mutation (ICM) is a well-known characteristic of the Celtic languages, but it is still not fully understood. It consists of systematic phonological alternations of word-initial consonants that are triggered by morphosyntactic environments. ICM is found in all languages within the Celtic family, although the particular alternations and triggers vary between languages.

As an example, consider the Irish word /*broːg*/ 'shoe'.[1] When preceded by the definite article /*an*/, the initial consonant is altered, giving /*an vroːg*/ 'the shoe'. Furthermore, when it is employed as the complement of a prepositional phrase, the initial consonant undergoes a different mutation, giving /*ər an mroːg*/ 'on the shoe'. The Irish word for 'shoe' therefore has three distinct forms: the 'radical' form /***b**roːg*/, the 'lenited' form /***v**roːg*/ and the 'eclipsed' form /***m**roːg*/.

The above example shows how the morphosyntactic context determines which of the three forms of the word is used. There are dozens of such 'triggering environments' in Irish (and in the other Celtic languages), and they do not follow any discernible unifying pattern. Furthermore, each initially-occurring consonant in Irish undergoes a unique set of mutations, so that the lenited and eclipsed forms cannot always be predicted by applying a simple phonological rule. The result is a complex system that combines elements of phonology, morphology and syntax into a single phenomenon.

Because ICM occurs at this interface between phonology, morphology and syntax, there is much debate about its status in the grammar, with some scholars arguing for a phonological explanation and others for a morphological viewpoint. However, neither perspective has been able to fully account for the complexity of the data. It has become increasingly clear that a complete explanation will require treatment of both aspects of the phenomenon simultaneously.

This project studies the grammatical mechanism of initial consonant mutation within the framework of Optimality Theory (OT). Optimality Theory proposes that surface forms of language arise through competition between sets of universal constraints. These constraints are ranked in a hierarchy that is language-specific (Kager, 1999). Depending on the arrangement of constraints within the hierarchy, a wide range of phenomena can be accurately predicted. While OT has traditionally been applied to phonology, it is in fact a general theory of grammar and can be equally well applied to the fields of morphology and syntax. It is this aspect of OT that lends itself particularly well to the description of ICM, which occurs at the interface of these three areas.

The purpose of this dissertation is to outline how Optimality Theory can be applied to the problem of initial consonant mutation in Modern Irish. In particular, it will

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[1] The examples in this dissertation are presented in phonemic transcription, with the aid of an online phonetisation application produced by the Phonetics and Speech Laboratory at Trinity College Dublin (Ní Chasaide, 2017).

demonstrate the benefits gained by taking an integrated approach, which does not give undue precedence to phonology or morphosyntax.

It is hoped that this approach will provide some insight into the status of the mutations within the Celtic languages, and particularly in Irish. In addition, by considering the phonological alternations and triggering mechanism together, it will help to advance understanding of the relationship between phonology, morphology and syntax, fields which are traditionally considered as distinct.

The remainder of this work is organised as follows: **Section 2** will take a closer look at the phenomenon of initial consonant mutation, providing a detailed description of the Irish data. **Section 3** will describe and evaluate some of the major theories that have been proposed to account for ICM. **Section 4** will introduce Optimality Theory as a suitable framework for the study of ICM, arguing that OT is particularly suited to phenomena at the interface of grammatical components. **Section 5** will explore how Optimality Theory can be used to account for initial consonant mutation, with reference to the Irish data provided in Section 2. It will conclude with an evaluation of the effectiveness of OT for dealing with ICM in Irish. Finally, **Section 6** will provide an overview of the arguments presented in the dissertation, and give an indication of possible future lines of research.

2 Initial Consonant Mutation in Modern Irish

2.1 Initial consonant mutation

The term 'initial consonant mutation' refers to the alternation of a word-initial consonant with another phonetically distinct consonant in specific morphosyntactic environments. Initial consonant mutations are unusual because they exist at the interface of phonology, morphology and syntax. Since most major theories of grammar require these modules to be treated separately, ICM poses a major challenge to linguistic theorists.

ICM is relatively rare cross-linguistically. Apart from the Celtic languages, the only languages known to exhibit initial consonant mutation (in the sense described here) are Nias (Austronesian, Indonesia), Nivkh (isolate, Eastern Russia) and Mundurukú (Tupian, Central Brazil) (Iosad, 2010).

The rarity of ICM raises the question of how it came to exist in the first place. The mutations were originally a purely phonetic occurrence, under which the status of an initial consonant was conditioned by the ending of the previous word via external *sandhi* effects (P. Russell, 1995, p. 249). For example, in Old Irish, the placement of an initial consonant in an intervocalic or post-nasal position would induce changes in the phonetic realisation of that consonant (Hickey, 2014, p. 237). However, the loss of these automatic conditioning factors (for example, through the loss of final syllables) led to the reanalysis of these *sandhi* changes as grammatically relevant. Once grammaticalised, the mutations started to be used functionally, and spread throughout the language via analogical change.

This project focuses on the theory of initial consonant mutation in Modern Irish. Modern Irish has two distinct types of ICM, termed 'lenition' and 'eclipsis'.[2] The remainder of this chapter will describe the phonological alternations and triggering environments for each of these mutation types, and highlight some points of particular interest which will be explored in later chapters.

2.2 Introduction to the Irish data

Irish (*Gaeilge*) is one of three Goidelic languages from the Celtic branch of the Indo-European family, the other two being Manx and Scottish Gaelic (Simons & Fennig, 2017). According to the European Commission, it had over 160,000 L1 and 1,000,000 L2 speakers in 2012. Native speakers are largely concentrated in the *Gaeltacht* (Irish-speaking) regions along the western coasts and isles of Ireland. Irish has constitutional status as the national language of the Republic of Ireland, and is taught as an official language in schools throughout the country.

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[2] Note that these are the terms used in traditional Irish grammars to refer to the initial consonant mutations of Modern Irish. In particular, the use of the term 'lenition' here is distinct from the usual definition of lenition as a weakening of consonants more generally (Hannahs, 2011, p. 7).

Irish can be broken down into three major dialects – Donegal, Connacht and Munster. Because of this dialectal variation, it is impossible to present a complete and consistent description of the ICM data for Modern Irish as a whole. Instead, this project focuses principally on *An Caighdeán Oifigiúil*, the official standard variety of Irish that is taught in schools (Rannóg an Aistriúcháin, 2017). Sections 2.3-2.5 will follow this standard, while Section 2.6 will discuss some of the ways in which the dialects of Irish differ in their realisations of initial consonant mutation.

2.3 Phonological alternations

Before introducing the phonological alternations associated with initial consonant mutation in Irish, it is necessary to provide a brief overview of the Irish consonantal system. Modern Irish has two distinct sets of consonants, palatalised (slender) and non-palatalised (broad), as shown in Table 1, adapted from Ó Siadhail (1989, p. 82). Note that the phonemes in parentheses are those that only occur as a result of consonant mutation, and therefore do not appear in word-initial positions in the radical forms of words.

Table 1: Modern Irish consonantal system

Broad:	*p*	*b*	*f*	(*v*)	*m*	*t*	*d*	*s*	*n*	*l*	*r*	*k*	*g*	(*x*)	(*ɣ*)	(*ŋ*)	(*h*)
Slender:	*pʲ*	*bʲ*	*fʲ*	(*vʲ*)	*mʲ*	*tʲ*	*dʲ*	*ʃ*	*nʲ*	*lʲ*	*rʲ*	*c*	*ɟ*	(*ç*)	(*j*)	(*ŋʲ*)	

2.3.1 Lenition

The first mutation type to be considered is lenition (*séimhiú*). Table 2, adapted from Green (2006, p. 1950), presents the phonological alternations for lenition in Modern Irish.[3]

The first thing to notice is that in the vast majority of cases, the form of the lenited consonant is independent of the palatalisation of the radical form. Thus the bilabial stops /*p*, *pʲ*/ are both lenited to labiodental fricatives /*f*, *fʲ*/. Like their radical forms, these differ only in palatalisation. The only exceptions to this rule occur in cases where there is free variation between phones in either the palatalised or non-palatalised lenited form. For example, the unpalatalised /*t*/ is lenited to /*h*/, while its palatalised counterpart /*tʲ*/ can be lenited to either /*h*/ or /*xʲ*/. However, this observation can be explained through a process of 'glide formation', a separate rule that is independent of lenition (Ní Chiosáin, 1991, pp. 23, 154-157). Because of this, the remainder of this discussion will disregard the distinction between palatalised and non-palatalised consonants under lenition.

Note that although the alternations in Table 2 cannot be predicted from a single simple phonological rule, they do not completely lack a pattern. For example, all bilabial

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[3] Note that lenition of /*s*/ does not occur when it directly precedes /*k*, *f*, *m*, *p*, *t*/.

Table 2: Phonological alternations for lenition in Irish

Radical form		**Lenited form**	
Phonemic	Orthographic	Phonemic	Orthographic
/p, pʲ/	⟨p⟩	*/f, fʲ/*	⟨ph⟩
/t, tʲ/	⟨t⟩	*/h, h∼xʲ/*	⟨th⟩
/k, kʲ/	⟨c⟩	*/x, xʲ/*	⟨ch⟩
/b, bʲ/	⟨b⟩	*/w∼v, vʲ/*	⟨bh⟩
/d, dʲ/	⟨d⟩	*/ɣ, ɣ∼j/*	⟨dh⟩
/g, gʲ/	⟨g⟩	*/ɣ, ɣ∼j/*	⟨gh⟩
/f, fʲ/	⟨f⟩	∅	⟨fh⟩
/s, ʃ/	⟨s⟩	*/h, h∼xʲ/*	⟨sh⟩
/m, mʲ/	⟨m⟩	*/w∼v, vʲ/*	⟨mh⟩
/n, nʲ/	⟨n⟩	*(no change)*	
/l, lʲ/	⟨l⟩	*(no change)*	
/r, rʲ/	⟨r⟩	*(no change)*	

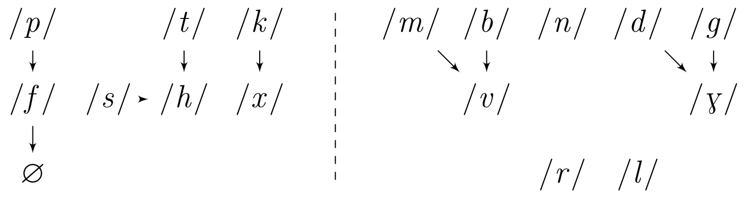
and velar stops */p, b, m, k, g/* are shifted to the "closest" fricative in the consonantal inventory (while retaining their voicing quality). Thus the bilabial stops are lenited to labiodental fricatives */f, v/*, while the velar stops are lenited to velar fricatives */x, ɣ/*.

The alveolar stops */t, d/* also become fricatives when lenited, although rather than shifting to alveolar fricatives as might be expected, they lenite to the glottal fricative */h/* and the voiced velar fricative */ɣ/* respectively. Even more surprisingly, the alveolar fricative */s/* lenites to the glottal fricative */h/*. The remaining alveolar consonants */n, l, r/* are unchanged under lenition.

One particularly interesting feature from the Irish lenition data is the deletion of */f/* under lenition. This deletion presents problems for phonological theories of mutations, and will be discussed further in Sections 2.5 and 3.3.

See Figure 1 for a schematic representation of phonological alternations under lenition. In this diagram, voiced and voiceless consonants are separated, while stops, fricatives and liquids are found in the first, second and third rows, respectively.

Figure 1: Schematic of Irish phonological alternations under lenition



Finally, note that in certain specific environments the alveolar fricative */s/* does not undergo its usual lenition to */h/*, but is instead mutated to */t/* ⟨ts⟩ (see Section 2.4.1 for more details).

2.3.2 Eclipsis

The second lenition type in Modern Irish is eclipsis (*urú*). Table 3, adapted from Green (2006, p. 1950), presents the phonological alternations for eclipsis.

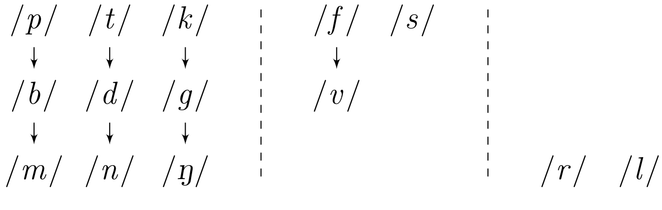
Table 3: Phonological alternations for eclipsis in Irish

Radical form		**Eclipsed form**	
Phonemic	Orthographic	Phonemic	Orthographic
/p, pʲ/	⟨p⟩	*/b, bʲ/*	⟨bp⟩
/t, tʲ/	⟨t⟩	*/d, dʲ/*	⟨dt⟩
/k, kʲ/	⟨c⟩	*/g, gʲ/*	⟨gc⟩
/b, bʲ/	⟨b⟩	*/m, mʲ/*	⟨mb⟩
/d, dʲ/	⟨d⟩	*/n, nⁿ/*	⟨nd⟩
/g, gʲ/	⟨g⟩	*/ŋ, ŋʲ/*	⟨ng⟩
/f, fʲ/	⟨f⟩	*/v, w∼vʲ/*	⟨bhf⟩
/s, ʃ/	⟨s⟩	*(no change)*	
/m, mʲ/	⟨m⟩	*(no change)*	
/n, nʲ/	⟨n⟩	*(no change)*	
/l, lʲ/	⟨l⟩	*(no change)*	
/r, rʲ/	⟨r⟩	*(no change)*	

As with lenition, the form of the eclipsed consonant is independent of the palatalisation of the radical form, except in the case of free variation between */w/* and */v/* in the eclipsed form of unpalatalised */f/*, which can again be dealt with independently via glide formation. Therefore, as before, the distinction between palatalised and non-palatalised consonants will be disregarded in this discussion.

A schematic representation of phonological representations under eclipsis can be found in Figure 2. In this diagram, the first, second and third rows contain the voiceless stops/fricatives, voiced stops/fricatives, and nasals/liquids, respectively.

Figure 2: Schematic of Irish phonological alternations under eclipsis



The eclipsis data in Table 3 and Figure 2 presents a much more regular pattern than that of lenition. The general pattern is that of a chain-shift: voiceless segments become voiced, voiced stops are nasalised, and liquids remain unchanged.[4] The only exception to this rule is in the case of the voiceless alveolar fricative */s/*, which like the liquids remains

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[4] Note that although the term 'chain-shift' is traditionally used by historical linguists to describe structural shifts in the sounds of a language over time, it has more recently been adopted by scholars of ICM for the situation described here (Ní Chiosáin, 1991; Gnanadesikan, 1997; Wolf, 2007; Iosad, 2010).

unchanged under eclipsis. However, there are some dialects of Irish in which /*z*/ is found to be the eclipsed form of /*s*/, which would be in keeping with this pattern (Ó Siadhail, 1989, p. 114 - see also Section 2.6.2).

The main problem with the eclipsis data is therefore not the lack of regularity in the data, but rather the existence of such a chain-shift. For example, if the eclipsis mutation environment favours nasal consonants, then why do the voiceless stops stop only halfway along the chain, becoming voiced but not nasalised? On the other hand, if the mutation environment favours only voicing, then why do the voiced stops shift at all? These questions pose a challenge to a phonological explanation of eclipsis.

2.4 Triggering environments

The phonological alternations described in the previous section are triggered on the initial consonants of words in specific morphosyntactic contexts. In Irish, the phenomenon of initial consonant mutation is restricted to the lexical (content) word categories – namely, nouns, adjectives and verbs. This section will present the triggering environments for lenition and eclipsis in Irish, and is based on the description provided by the Christian Brothers (1960, pp. 24-42, 270).

2.4.1 Lenition

The triggering environments for lenition can be found in Table 4 below. Note that Table 4 only provides an overview of lenition contexts, and that there are many other minor rules and exceptions – for full details see Christian Brothers (1960, pp. 24-38, 268-270). Explanations for the abbreviations used in the table can be found in Appendix A.

The triggering environments for nouns and verbs have been laid out in two columns: ‘word properties’ and ‘syntactic context’. The reason for this is to make it explicitly clear that lenition triggers generally cannot be described as purely morphological or purely syntactic. Instead, they must be considered as a combination of these two factors. For example, for a noun, knowledge of the gender, case and number alone cannot tell us its lenition status. On the other hand, knowledge of the noun’s position within a syntactic structure is often not enough, unless its gender, case and number are provided also. It is only when both aspects are considered that the mutation status of a word can be determined.

Note that in the environments marked with an asterisk (*), lenition does not occur for the alveolar consonants /*t, d, s*/.

Table 4: Triggering environments for lenition in Irish

(A)	**Nouns and Verbal Nouns**	
	Word properties	*Syntactic context*
(A1)*	NOM SG F	After definite article *an* e.g. *an **bh**ean* ‘the woman’
(A2)*	GEN SG M	After definite article *an* e.g. *mac an **fh**ir* ‘the man’s son’
(A3)*	DAT SG	After *den, don, sa*∼*san* ‘from the, to the, in the’ e.g. *sa **fh**reagra* ‘in the answer’
(A4)	VOC	After the vocative particle *a* e.g. *a **bh**ean!* ‘woman!’
(A5)	–	After posessive adjectives *mo, do, a* ‘my, your, his’ e.g. *mo **mh**ac* ‘my son’
(A6)*	–	After *aon, chéad* ‘one, first’ e.g. *an chéad **bh**liain* ‘the first year’
(A7)	SG	After numerals *dhá, trí, ceithre, cúig, sé* ‘two, three, four, five, six’ e.g. *cúig **ph**unt* ‘five pounds’
(A8)	–	After prepositions *a, de, do, faoi, mar, ó, roimh, trí, um* ‘to, from, to, under, as, from, before, through, at’ e.g. *mar **dh**uine* ‘as a person’
(A9)	–	After *ar* ‘on’, unless describing a state e.g. *ar **dh**eis* ‘on the right’; *ar díol* ‘for sale’
(A10)	–	After *idir* ‘both, between’, when used in the sense of ‘both’ e.g. *idir **fh**ir agus **mh**ná* ‘both men and women’
(A11)*	–	After *gan* ‘without’, unless the noun is qualified, a proper noun, or part of a fixed phrase e.g. *gan **ch**iall* ‘without sense’

Continued on next page

Table 4 – *Continued from previous page*

(A12)	–	After *thar* ‘over’, unless noun is unqualified and generic in meaning e.g. *thar **bh**arr an chnoic* ‘over the top of the hill’; *thar muir* ‘overseas’
(A13)	GEN INDEF	When governed by a plural noun ending in a palatalised consonant, unless two alveolar consonants come together across the word boundary e.g. *buidéil **bh**ainne* ‘bottles of milk’
(A14)	GEN INDEF	When governed by a feminine singular noun, unless two alveolar consonants come together across the word boundary e.g. *teanga **dh**úchais* ‘native language’
(A15)	GEN DEF	When not the object of a verbal noun e.g. *cuan **Bh**aile Átha Cliath* ‘Dublin Bay’
(A16)	–	After the past/conditional forms of the copula: *ba, ar, gur, nár* e.g. *ba **dh**uine mór é* ‘he was a big person’
(B)	**Adjectives**	
	Syntactic context	
(B1)	After a SG F noun (not GEN) e.g. *obair **mh**aith*, ‘good work’	
(B2)	After a GEN/VOC SG F noun e.g. *bád Sheáin **Mh**óir* ‘Big Seán’s boat’	
(B3)	After a PL noun finishing with a palatalised consonant e.g. *na heitleáin **dh**earga* ‘the red aeroplanes’	
(B4)	After *beirt* ‘two people’, or after a noun qualified by *beirt* e.g. *beirt **bh**eaga* ‘two small people’; *an bheirt fhear **bh**eaga* ‘the two small men’	
(B5)	After a SG noun qualified by numerals *dhá* ‘two’ - *trí déag* ‘nineteen’ e.g. *trí long déag **mh**óra* ‘thirteen big ships’	

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Table 4 – *Continued from previous page*

(B6)	After *idir* ‘both, between’, when used in the sense of ‘both’ e.g. *páistí idir **bh**eag agus **mh**ór* ‘children both big and small’	
(B7)	After the past/conditional forms of the copula: *ba, ar, gur, nár* e.g. *ba **bh**reá é* ‘it was good’	
(C)	**Verbs**	
	Word properties	*Syntactic context*
(C1)	PAST/HAB/CON	When the verb is in its independent form[5] e.g. ***mh**olamar* ‘we praised’
(C2)	PAST.IND	Following any verbal particle e.g. *ar **th**it sé?* ‘did he fall?’
(C3)	Not PAST.IND	Following the verbal particle *ní* (NEG) e.g. *ní **bh**risfidh sé* ‘it will not break’
(C4)	Not PAST.AUT	Following the direct relative particle *a* e.g. *an fear a **sh**ábhálfaidh an tír* ‘the man who will save the country’
(D)	**Compound Words**	
(D1)	The second constituent of a compound word, unless two alveolar consonants come together at the joining point e.g. *droch**dh**uine* ‘bad person’; *ard**s**agart* ‘high priest’	

The first thing to notice in Table 4 is the wide range of environments that trigger lenition in Irish. It is clear at a glance that this mutation permeates the entire language, affecting nouns, adjectives and verbs in a broad variety of contexts. Furthermore, as mentioned above, neither the properties of the word itself, nor its syntactic context alone can determine a word’s lenition status. Thus the trigger cannot be considered as originating solely from the environment, since properties intrinsic to the target word itself are often just as important in triggering lenition.

Another interesting point is that, although the mutations tend not to carry functional load, there are some cases in Table 4 in which the presence or absence of lenition is crucial to the successful interpretation of a phrase. For example, in environment (A10), lenition is used to distinguish between two senses of the word *idir* ‘both, between’. Compare the following examples:

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[5] Irish verbs come in three forms: independent, dependent and relative (Christian Brothers, 1960, pp. 173-174). The independent form is used for a positive statement forming the principle clause in a sentence, e.g. *Chuaigh mé* ‘I went’.

(1) a. *idir fir agus mná*
[idir] men and women
'between men and women'

b. *idir* ***fh**ir* *agus* ***mh**ná*
[idir] men.L and women.L
'both men and women'

The only difference between (1-a) and (1-b) is the lenition value of *fir* 'men' and *mná* 'women'. However, this difference has a direct effect on the semantic interpretation of the word *idir*. In the absence of lenition, it is interpreted in the sense of 'between' (1-a), while the presence of lenition on the nouns shifts the sense to 'both' (1-b). Note that the word *idir* remains identical in the two cases, with the functional load being carried entirely by the lenition.

A similar situation is found in environment (A5). The Irish third person possessive pronoun *a* can carry three possible senses, masculine ('his'), feminine ('her') and plural ('their'). Although the form of the word is the same in all cases, the distinction is carried by the mutation value of the possessed noun, as in the following examples.

(2) a. *a* ***ch**óta*
[a] coat.L
'his coat'

b. *a cóta*
[a] coat
'her coat'

c. *a* ***gc**óta*
[a] coat.E
'their coat'

As before, the only difference between (2-a), (2-b) and (2-c) is the mutation value of *cóta* 'coat'. In this case the senses 'his', 'her' and 'their' are distinguished via lenition (2-a), no mutation (2-b) and eclipsis (2-c), respectively (for eclipsis, see Table 5 (E3) in Section 2.4.2).

Another important example is verb tense, where lenition is employed to indicate past tense or conditional mood (C1).

Finally, the data in Table 4 adds further support to the notion of initial consonant mutation as an interface problem. Usually, the mutations themselves are considered as part of the phonology, while the triggering environments are provided solely by the morphosyntax. By and large, the evidence provided so far supports this view. However, in some cases this distinction is less clear-cut.

Consider environment (A13), which requires lenition on an indefinite noun in the genitive case only when it is governed by a plural noun ending in a palatalised consonant.

Here we see an example of phonological information affecting the triggering environment, along with morphology and syntax.

As with the phonological alternations (Section 2.3), alveolar consonants tend not to follow the expected patterns in all cases. The asterisks in Table 4 indicate that five of the twenty-seven environments listed do not trigger lenition in words beginning with alveolar consonants. Environments (A13), (A14) and (D1) also contain specific restrictions on alveolar consonants, blocking lenition if two such consonants come together at the join between the two constituents of a compound word.

Perhaps the most surprising example of the conflation of phonology and triggering environment occurs in the case of the alveolar fricative /*s*/ (briefly mentioned at the end of Section 2.3.1). In triggering environments (A1) (Example (3-a)) and (A2) (Example (3-b)), Irish nouns beginning with /*s*/ ⟨s⟩ are not lenited to /*h*/ ⟨sh⟩ as usual, but instead are mutated to /*t*/ ⟨ts⟩, a phenomenon we will term 'anti-lenition' (Christian Brothers, 1960, pp. 41-42):

(3) a. *an* ***ts**lat*
the rod.aL
'the rod'

b. *teach an* ***ts**agairt*
house the priest.GEN.aL
'the priest's house'

This is surprising for two reasons – firstly, because there does not seem to be any explicit reason why these environments should be treated differently from any of the others; and secondly, because the mutation /*s*/ to /*t*/ is contrary to the general phonological patterns of lenition observed in Figure 1. Any theory of ICM will need to account for this anomaly.

2.4.2 Eclipsis

The triggering environments for eclipsis can be found in Table 5 below, based on Christian Brothers (1960, pp. 39-41, 268-270). As in Table 4, an asterisk (*) indicates that eclipsis does not occur for the alveolar consonants /*t, d, s*/ in that environment.

Table 5: Triggering environments for eclipsis in Irish

(E)	**Nouns**	
	Word properties	*Syntactic context*
(E1)*	DAT SG	After preposition + definite article *an* e.g. *ar an **mb**ád* 'on the boat'

Continued on next page

Table 5 – *Continued from previous page*

(E2)	GEN PL	After plural definite article *na* e.g. *scoil na **gc**ailíní* ‘the girls’ school’
(E3)	–	After plural possessive adjectives *ár, bhur, a* ‘our, your, their’ e.g. *ár **bp**áiste*, ‘our child’
(E4)	–	After numerals *seacht, ocht, naoi, deich* ‘seven, eight, nine, ten’ e.g. *seacht **nd**uine* ‘seven people’
(E5)	–	After preposition *i* ‘in’ e.g. *i **mb**aile* ‘in a town’
(F)	**Adjectives**	
	Syntactic context	
(F1)	Before a noun, where the noun would be eclipsed (as in A1-A5) e.g. *i **ng**ach áit*, ‘in every place’	
(G)	**Verbs**	
	Word properties	*Syntactic context*
(G1)	Not PAST.IND	Following any verbal particle, except for *ní* (NEG) e.g. *imigh sula **bh**feicfidh siad tú* ‘go before they see you’
(G2)	Not PAST.REG	Following the indirect relative particle *a* e.g. *an poll a **dt**agann na coiníní as* ‘the hole that the rabbit comes out of’

While the range of triggering environments for eclipsis is not as large as those for lenition, it is clear from Table 5 that eclipsis is still found in a wide variety of contexts, affecting nouns, adjectives and verbs. Eclipsis does not usually carry functional load, except for after the word *a* ‘their’ in environment (E3), as described in the previous section (Example (2)).

As with lenition, there are certain cases in which eclipsis does not apply for alveolar consonants, namely in environment (E1). This is something that will need to be addressed in any theory of ICM.

2.5 Points of particular interest in the Irish data

The past few sections have highlighted some interesting aspects of initial consonant mutation, under the headings of 'phonological alternations' and 'triggering environments'. The purpose of this section is to reiterate the most important points, and to draw attention to the features of the Irish data which have caused the greatest difficulties for linguists attempting to understand the phenomenon. Table 6 summarises the main theoretical problems associated with ICM in Modern Irish.

Table 6: Summary of the theoretical problems associated with ICM

Problems with phonological alternations:
(i) Status of alveolar consonants
(ii) Mutation of /*s*/ to /*t*/ in some lenition environments
(iii) Deletion of /*f*/ under lenition
(iv) Existence of chain-shifts

Problems with triggering mechanism:
(v) Triggering environments that depend on phonology
(vi) Non-adjacency of triggers and targets
(vii) Precedence of certain triggering environments over others

General problems:
(viii) Lack of functional load
(ix) Conflation of phonology, morphology and syntax

The most obvious complication associated with the Irish data is the status of alveolar consonants. We have seen that alveolar consonants do not follow the expected patterns for phonological alternations under lenition, and that under eclipsis the alveolar fricative /*s*/ does not fit in with the general trends. Furthermore, both lenition and eclipsis possess triggering environments under which alveolar consonants exhibit no change at all. Upon closer inspection of Tables 4 and 5, it becomes apparent that these are precisely the environments in which an alveolar consonant directly precedes the mutating consonant in all cases. This connection is worth examining further. The mutation of /*s*/ to /*t*/ in environments (A1) and (A2) must also be explained.

Another difficulty with the Irish data concerns the deletion of /*f*/ under lenition. No theory of mutation has been found that can fully account for this phenomenon, with most theorists simply listing it as an exception requiring further analysis (Green, 2006; Swingle, 1993; Wolf, 2007). One interesting point to note is that if the original segment is palatalised (/f^j/), then it leaves behind a "palatal offglide" upon deletion. More specifically, this means that after a proclitic such as *an* 'the' or *d'* (past tense marker), the palatalisation is retained and attaches itself to the preceding consonant (Gussmann, 1986, p. 894). For example, compare *fuinneog* /*fin*^{j}*oːg*/ 'window', *an fhuinneog* /*ə**n** in*^{j}*oːg*/ 'the window' (which has no palatalisation in the clitic-final consonant) with *feoil*

/*fʲoːlʲ*/ ‘meat’, *an fheoil* /*ə**nʲ** oːlʲ*/ ‘the meat’ (which does have palatalisation). This fact is problematic for theories of mutations as pure morphology (see Section 3.4.1).

A further problem with the phonological alternations themselves is the existence of chain-shifts, particularly in the eclipsis data (see Section 2.3.2). This seems to indicate that the alternations cannot be predicted via a simple phonological rule.

There are also difficulties associated with the triggering mechanisms for mutations. For example, while most triggering environments are defined by the morphosyntax, environment (A13) depends explicitly on the phonology of the preceding word, and there are several environments that treat alveolar constants differently.

Another interesting feature of the triggering mechanism is the issue of non-adjacency. For example, consider the following example (Christian Brothers, 1960, p. 25):

(4) *trí* ***sh**ioc* *agus* ***sh**neachta*
through ice.L and snow.L
‘through ice and snow’

Environment (A8) requires lenition following the word *trí* ‘through’. However, note that this lenition environment applies to both *sioc* ‘ice’ and *sneachta* ‘snow’, even though the latter is not adjacent to the trigger. Thus it appears that the preposition *trí* induces mutation not solely in words adjacent to it, but in any noun that is a complement of the prepositional phrase. This feature of non-adjacency causes problems for affixational theories of ICM (see Sections 3.2–3.3).

A further challenge for theories of ICM is to understand what happens when a word falls into two conflicting triggering environments simultaneously. For example, it is found that environment (E3) takes precedence over the rule for *dhá* ‘two’ in environment (A7) when they come together (Christian Brothers, 1960, p.40):

(5) a. *ár* *dhá* ***gc**apall*
our two horse.E
‘our two horses’

b. **ár* *dhá* ***ch**apall*
our two horse.L
‘our two horses’

Note that (5-a) follows the rule for environment (E3) (eclipsis), while the ungrammatical (5-b) follows the rule for environment (A7) (lenition). This observation hints that there may be a hierarchy of triggering environments, with (A7) ranked higher than (E3).

One general issue that needs to be explained is why consonant mutations have remained part of the language at all, given their lack of functional load. As Thomas (1984, p. 234) says, “the most amazing feature of the mutations [...] is the persistent nature of the alternations in some environments, considering their low information value and their marginality to the system [...] it might have been expected that they would have disappeared long ago". Thomas was referring to the Welsh mutations, but the exact same could be said for the mutations in Modern Irish. With a few exceptions (see Sections 2.4.1 and 2.4.2), the initial consonant mutations in Irish carry no information at all. Their continuance in the language is a puzzle that cannot easily be explained.

Overall, the greatest challenge for grammatical theorists is to understand how the initial consonant mutation brings together the fields of phonology, morphology and syntax. We have seen how the data from Modern Irish conflates these fields in a variety of ways. The data suggests that an integrated approach, encompassing elements of phonology and morphosyntax, is the only way to reach a full understanding of the phenomenon.

2.6 Dialectal variation

As mentioned in Section 2.2, the descriptions of Irish data provided so far have focused on *An Caighdeán Oifigiúil*, the official standard variety of Irish. However, note by its nature as an "official" taught standard, rather than a variety passed down from parent to child, it does not necessarily reflect the living language of Irish. For this reason, it is important to be aware of the ways in which the dialects of Ireland differ from this official standard. This section will highlight some aspects of ICM for which the dialects of Ireland vary.

Native speakers of Irish are primarily concentrated in the *Gaeltacht* regions of Ireland, which are depicted in Figure 3, from Kallen (1997, p. xv, Map 2). Note that the *Gaeltacht* regions depicted in the map can naturally be divided into three principal dialectal areas, Donegal in the north, Connacht in the west (comprising the Mayo and Galway *Gaeltachtaí*) and Munster in the south (comprising the Kerry, West Cork and Waterford *Gaeltachtaí*).[6] Here we will look at each of these dialects in turn.

2.6.1 Donegal

The most noticeable way in which the dialects of Donegal differ from the official standard is in environment (E1). Instead of undergoing eclipsis after a preposition + definite article *an*, Donegal varieties of Irish favour lenition in these circumstances (O'Rahilly, 1976, p. 169). Hence the following examples (Ó Siadhail, 1989, p. 127):

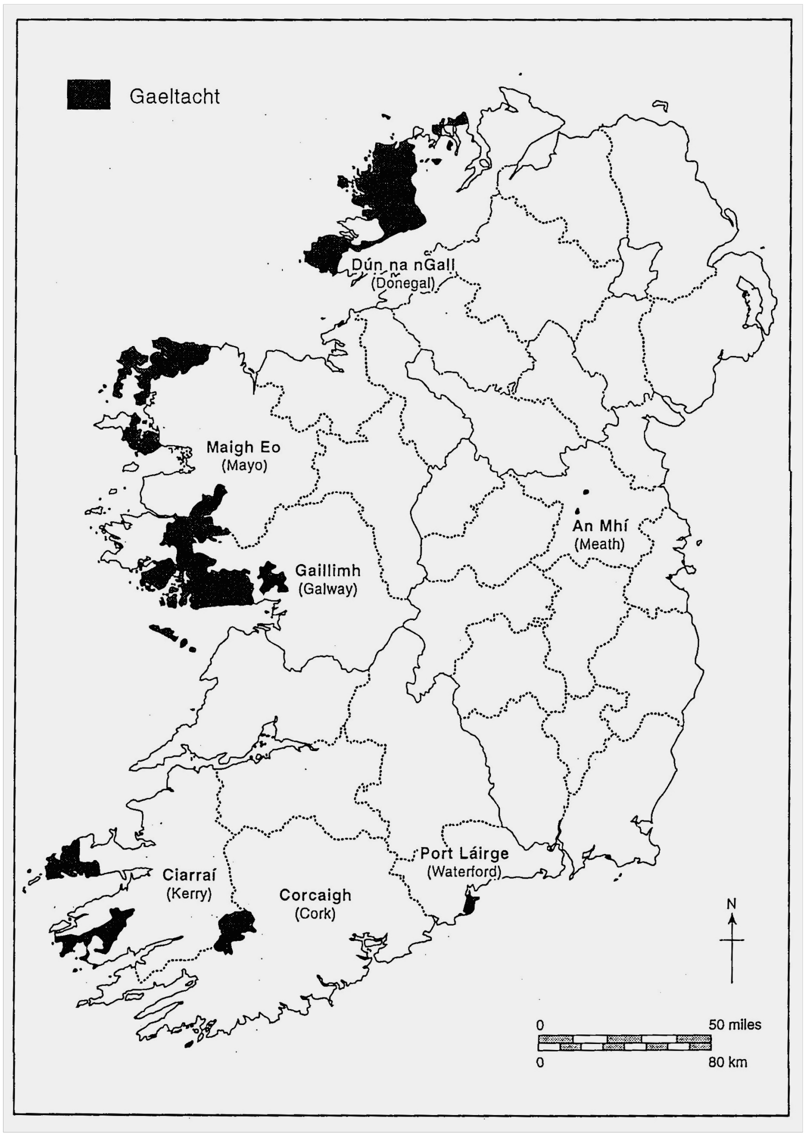
(6) a. *ar an* ***bh****ád*
on the boat.L
'on the boat'

b. *fríd an* ***fh****uinneog*
through the window.L
'through the window'

---

[6] There is also a small *Gaeltacht* region in Ráth Chairn, Co. Meath. This is the youngest official *Gaeltacht*, formed when families from Conamara settled there in 1935.

Figure 3: Location of the current designated Gaeltacht regions in Ireland



This feature can be attributed to Scottish Gaelic influence, and has also been attested in Manx (O'Rahilly, 1976, p. 169).

Another feature that differs from the standard is the existence of phonemes /ʟ/ and /ɴ/, the tense forms of /*l*/ and /*n*/ respectively. In Donegal Irish, lenition is sometimes expressed as loss of this tension (Ó Siadhail, 1989, p. 113). However this contrast is dying out and may be nearly extinct today (Green, 2006, p. 1950).

2.6.2 Connacht

In Connacht varieties of Irish, nouns beginning with /*s*/ in environment (E1) behave as though they are in environment (A1) (O'Rahilly, 1976, p. 213-214). In other words, they are left unmutated if masculine, and are mutated to /*t*/ if feminine (anti-lenition). Thus for a masculine noun *sagart* ‘priest’ and a feminine noun *sráid* ‘street’ we have:

(7) a. *ar an sagart*
on the priest
‘on the priest’

b. *ar an **ts**ráid*
on the street.aL
‘on the street’

Like Donegal Irish, some varieties of Connacht Irish express lenition of /*n*/ and /*l*/ through loss of tension (Ó Siadhail, 1989, p. 113), but as in Donegal, this feature is dying out.

The mutation of /*f*/ is somewhat unpredictable, with some varieties of Connacht Irish failing to lenite /*f*/-initial words in some environments. Examples (8) and (9) demonstrate this for environments (B1) and (A8), respectively (Ó Siadhail, 1989, p.113).

(8) a. *feoil fuar*
meat cold
‘cold meat’

b. **feoil **fh**uar*
meat cold.L
‘cold meat’

(9) a. *a leithéide de focal*
PRT such of word
‘such a word’

b. **a leithéide de **fh**ocal*
PRT such of word.L
‘such a word’

Finally, there are some instances recorded of /*s*/ mutating to /*z*/ under eclipsis in varieties of Connacht Irish (Ó Siadhail, 1989, p. 114). This is interesting because it aligns well with the phonological patterns discussed in Section 2.3.2.

2.6.3 Munster

Just as in Connacht, feminine nouns in environment (E1) undergo anti-lenition in Munster (O’Rahilly, 1976, p. 213-214). Furthermore, in West Munster, the restrictions on dental consonants in this environment do not apply. Compare (10-a) (Munster) with (10-b) (elsewhere).

(10) a. *ón **nd**oras*
from.the door.E
‘from the door’

b. *ón* *doras*
from.the door
'from the door'

In some Munster dialects, adjectives modifying nouns in eclipsing environments (E1) and (E2) are themselves eclipsed (O'Rahilly, 1976, pp. 214, 271). This is a relic of an earlier variety of Irish, and can be seen in (11-a) and (11-b).

(11) a. *ar an bhfear* ***mb****ocht*
on the man.E poor.E
'on the poor man'

b. *teach na bhfear* ***mb****eag*
house the.GEN.PL man.GEN.PL.E small.GEN.PL.E
'the house of the small men'

Finally, some varieties of Munster Irish express lenition of /r/ through palatalisation (Ó Siadhail, 1989, p. 112). However, this feature is rare, and generally only found among older speakers.

3 Review of Previous Approaches

3.1 Theories of ICM

The greatest challenge for theories of ICM is to find a way to account for both the phonological and morphosyntactic data, and in particular, to understand how they interact with one another. As Hannahs (2011, p. 2808) puts it, the main difficulty faced by linguistic theorists studying initial consonant mutation is that "although the mutations affect the phonological shape of word forms, the alternations themselves may be triggered by non-phonological structures in a phonetically opaque way." Thus, in any theory of ICM there are two broad issues that must be addressed:

1. How can the nature of the alternations be characterised and understood phonologically?
2. What is the triggering mechanism for the mutations?

With regard to the first question, the main difficulty lies in the fact that the relationship between radical and mutation consonants tends not to follow a phonologically uniform pattern (see Section 2.3). Developing a theory to account for the full complexity of the data has proven to be a major challenge for phonologists. Responses to the second question focus on trying to find an appropriate mechanism by which lexical and syntactic information can trigger an apparently phonological effect. Although most approaches to Celtic mutations tend to focus on answering just one of these questions, the two are closely interlinked and should ideally be considered together.

This chapter will present some of the most important and influential analyses of initial consonant mutation in the Celtic languages. It will explore the extent to which they can be reconciled with the data discussed in Section 2 and evaluate the merits and shortcomings of each approach.

The chapter will begin with a short discussion of the classic paper by Hamp (1951), which was the first serious attempt to develop a grammatical theory of the Celtic mutations, through the use of morphophonemes. The remaining theories are grouped according to whether they give more weight to phonology, morphology or syntax; however, bear in mind that by necessity, any theory of ICM must give at least some reference to all three aspects of the grammar.

3.2 Hamp's morphophoneme theory

The first major theory of Celtic mutations was put forward by Hamp (1951), who argued in favour of morphophonemes as an explanation for the phenomenon. Hamp's morphophonemes are segmentally empty morphemes residing at the right edge of trigger words, which encode the phonological information required to produce the relevant mutation on the following word-initial segment. For example, lenition after the first person possessive pronoun *mo* 'my' (environment (A5)) can be explained by positing the existence of a lenition morphophoneme ***L*** at the end of this word. This morphophoneme acts on the following word-initial segment, converting it into its lenited counterpart. Consider Example (12), which presents the orthographic, phonemic and phonetic transcriptions of the Irish for 'coat' and 'my coat':

(12) a. *cóta* /*koːtə*/ → [*koːtə*] 'coat'
b. *mo chóta* /*mə****L*** *koːtə*/ → [*məxoːtə*] 'my coat'

Note how in (12-b), the morphophoneme ***L*** at the end of the first word causes the /*k*/ at the start of the second word to be realised as a fricative [*x*]. In a similar way to this, a morphophoneme ***E*** could be used to explain the phenomenon of eclipsis.

One advantage of Hamp's approach is the simplification of grammatical description on a synchronic level. In addition to providing an explanation for the initial consonant mutation phenomenon, the inclusion of morphophonemes can in some cases reduce the phonological inventory. This is certainly true in Irish – the inclusion of the lenition morpheme ***L*** reduces the number of phonemes significantly (i.e. by removing the nine phonemes in parentheses in Table 1).

Hamp's theory was, and remains, extremely influential for scholars of ICM. However, it does have some serious shortcomings. The theory focuses primarily on the triggering mechanism, without any attention to the phonological details of the alternations, or the rationale for these changes. Even more seriously, it cannot account for the existence of mutations that are triggered by nonadjacent proclitics; nor can it explain how properties of the target word (gender, number, etc.) influence the triggering process. Nevertheless, Hamp's paper inspired a new interest in the theory of Celtic mutations, and provided a solid basis on which other researchers could build their ideas.

3.3 Phonology-based approaches

3.3.1 Lenition within Dependency Phonology

Ó Dochartaigh (1979) provides a phonological discussion of Irish lenition within the framework of Dependency Phonology (DP). In DP, each phonological segment is regarded as a bundle of distinctive features, as is the case in transformational generative phonology (Chomsky & Halle, 1968, pp. 293 ff.). However, DP also involves the idea of dependency, a hierarchical system wherein either one feature dominates another, or the two are co-dependent. Within this system, manners of articulation can be viewed as different dependency relations between the features of vowel (V) and consonant (C) (Figure 4).[7]

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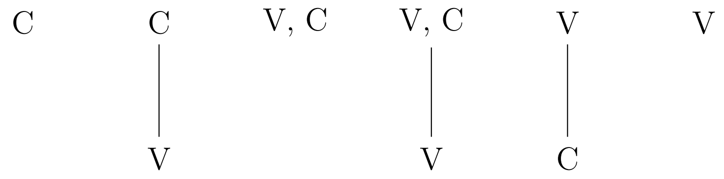
[7] In the DP figures, the dominant element is placed directly above the other elements of a segment, while co-dependent elements are placed side by side.

Figure 4: Manners of articulation expressed as dependency relations



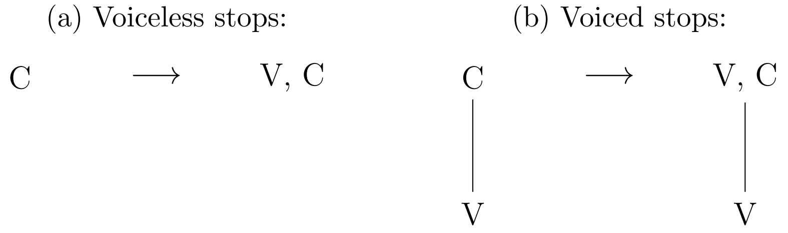
From left to right: voiceless stop, voiced stop, voiceless fricative, voiced fricative, sonorant consonant, vowel

Lenition in Irish follows a cross-linguistically observed pattern, moving down a scale involving progressive continuantisation and voicing (Lass & Anderson, 1975, p. 159). Ó Dochartaigh notes that within DP, this can be accounted for by increasing the prominence of V as you descend down the scale, through one of the following operations (listed in the preferred order of realisation):

- addition of a single V
- alteration of dependency relationships such that the segment is "V-er" than before
- deletion of a single C

For example, the lenition of labial and velar stops reflects the addition of a single V to the dominant part of the representation, transforming stops into fricatives (Figure 5).

Figure 5: Lenition of labial and velar stops in Dependency Phonology


(a) Voiceless stops:

(b) Voiced stops:

A major advantage of Ó Dochartaigh's approach is that it deals very well with some of the phonological problems mentioned in Table 6. This is achieved by proposing that articulatory and phonatory gestures are dealt with independently in the phonology.

For example, the exceptional status of alveolar consonants is explained by proposing an additional independent rule acting on articulatory gestures, which sends the feature [+ dental] to [∅] in lenition environments. This explains the lenition of [*t*, *s*] to [*h*], an articulatorily empty voiced fricative. The mutation of [*d*] to [ɣ] is accounted for by assuming that due to the absence of the predicted voiced [*h*] in the Irish phoneme inventory, the nearest available voiced fricative, [ɣ], is instead selected.

Furthermore, Ó Dochartaigh provides an explanation for the palatal offglide problem discussed in Section 2.5. He does this by separating out the primary articulatory, secondary articulatory and phonatory gestures, and proposing that the lenition environment deletes both primary articulatory features and phonatory features, while leaving the secondary features intact. These features are then available to dock onto the preceding consonant, as observed in the Irish data.

However, Ó Dochartaigh's theory makes no attempt to provide an explanation for eclipsis, and thus goes only halfway in accounting for the phonological alternations in Modern Irish.

3.3.2 A rule-based account within Feature Geometry Theory

Like Ó Dochartaigh, Ní Chiosáin (1991) claims that ICM is a result of rules, rather than morphological affixation. Her theory accounts for both lenition and eclipsis, and pays special attention to the blocking of mutation for alveolar consonants in certain cases (those marked with an asterisk in Tables 2 and 3). This is done within the framework of Feature Geometry Theory.

According to Ní Chiosáin, lenition involves two unordered rules, spirantisation and coronal delinking, along with a default rule, total deletion. Spirantisation is a feature fill-in rule, which assigns [+cont] to a word-initial segment unspecified for [cont]. The coronal delinking rule was added to account for the exceptional status of alveolar consonants (see Section 2.3.1), and involves the delinking of [coronal] as a primary place node to create "placeless" or laryngeal segments. Ní Chiosáin concurs with Ó Dochartaigh on the cause of mutation of [*d*] to [ɣ], noting also that "the relationship between laryngeal and dorsal fricatives" can be regarded as "natural" in Irish.

A default rule of total deletion is used whenever lenition is applied vacuously. This rule is included in order to account for the deletion of labiodental fricatives under lenition.

Ní Chiosáin's account of eclipsis captures the generalisation that eclipsis involves a chain-shift. Drawing on the work of Clements (1990), she proposes that eclipsis targets [-sonorant] segments, and involves a minimal increase along a sonority scale (Table 7).[8]

Table 7: Sonority scale for Irish phonology

	Obstruents		$/m/$	Nasals	Liquids	Vocoids
	(voiceless)	(voiced)				
Vocoid	−	−	−	−	−	+
Approximant	−	−	−	−	+	+
Sonorant	−	−		+	+	+
Voice	−	+	+	+	+	+

A major advantage of Ní Chiosáin's approach to mutation is that it can explain the blocking of mutation in heteromorphemic coronal clusters that arise as a result of com-

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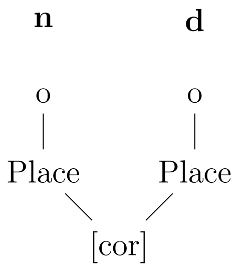
[8] Note that $/m/$ is considered in a separate category from the other nasal consonants; see Ní Chiosáin (1991) for more details.

pounding, prefixation and certain proclitics. Compare (13-a), in which lenition follows *sean* 'old', and (13-b), in which lenition is blocked.

(13) a. *sea*___n___ + ___m___*áthair* → *sean*___mh___*áthair*
old + mother → grandmother
'grandmother'
b. *sea*___n___ + ___d___*uine* → *sean*___d___*uine*
old + person → old.person
'old person'

In such cases, Ní Chiosáin suggests a rule of coronal fusion, whereby these derived coronal clusters have a shared [coronal] specification (Figure 6).

Figure 6: Coronal fusion in heteromorphemic coronal clusters



Drawing on the ideas of Schein & Steriade (1986), she proposes a general condition on structurally defined rules: "when a structural condition is imposed on a segment, no part of that segment may obey a contradictory structural condition" (Ní Chiosáin, 1991, p. 41). In the case of coronal clusters, this means that a word-initial segment that is place-linked to a preceding segment is no longer strictly word-initial, and thus does not obey the rules for initial consonant mutation.

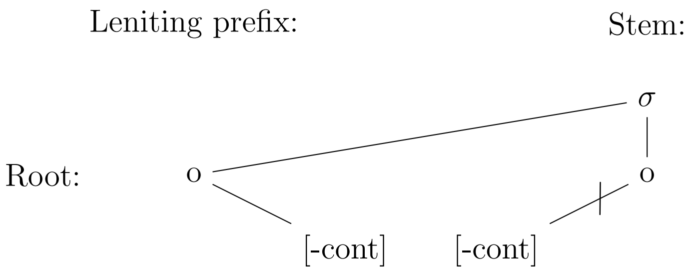
3.3.3 An affixational account

Swingle (1993) forgoes the rule-based theories of Ó Dochartaigh and Ní Chiosáin, in favour of an affixational account of ICM.

Previous affixational treatments of mutation analyse the triggering element as a floating autosegment which docks onto the initial consonant of the target word (Lieber, 1987). However, noting that such an analysis cannot explain the word-peripheral nature of the mutations, Swingle proposes that the trigger is an anchored subsegmental prefix that triggers dissimilatory processes in an adjacent stem segment. The analysis depends on the assumption that this prefix is syllabified into the initial onset.

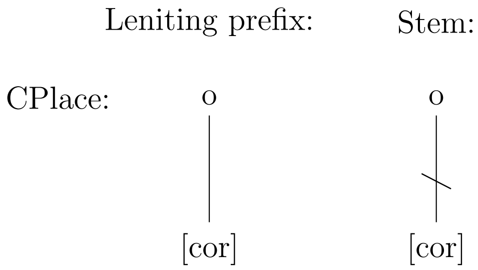
Swingle proposes that the lenition trigger is an anchored autosegment consisting of features [-cont] and [cor]. When this is prefixed onto a word with a [-cont] initial consonant, the second [-cont] is delinked, in accordance with the Sonority Sequencing Principle for onset clusters (Blevins, 1996, p. 80) (Figure 7).

Figure 7: Sonority-driven [-cont]-delinking



When it is prefixed onto a word with a [cor] initial consonant, the second [cor] is delinked, in order to correct a violation of the Obligatory Contour Principle (OCP) (McCarthy, 1981, p. 384) (Figure 8).

Figure 8: Correction of an OCP violation via [cor]-delinking



Swingle accounts for the lenition of */d/* to */ɣ/* via a process of "secondary place promotion", and explains the nonlenition of the coronal sonorants */r, l, n/* by suggesting that coronal fusion rather than coronal delinking takes place in these cases. The only phonological alternation that remains unaccounted for in this theory is the deletion of */f/*, which must be listed as an exception.

The primary achievement of Swingle's approach is that it traces the apparently irregular alternations of lenition to a common source, an anchored autosegmental prefix containing features [-cont] and [cor]. However, like the other phonology-based approaches, it fails to explain what triggers the appearance of this affix in the first place. To do this, one must look for solutions beyond the realm of pure phonology.

3.4 Morphology-based approaches

3.4.1 Mutations as pure morphology

Green (2006) argues that the initial consonant mutation cannot be analysed as phonological at all, but should be considered as an entirely morphological phenomenon, with mutated forms being listed as allomorphs in a word-based lexicon. He proposes that triggers are marked to select a particular mutation allomorph from the lexicon, in a parallel manner to case selection in Latin or Russian. Referring to the Irish mutation of *bróg* /*broːg*/ 'shoe', he claims that "the job of grammar is not to change /_**b**roːg_/ into /_**v**roːg_/ or /_**m**roːg_/ but rather to determine which form is used where" (Green, 2006, p. 3).

Green provides several arguments to back up his claim that the mutation process cannot be phonological. He maintains that no distinct set of phonological features can account for the behaviour of all consonants under the effect of a single mutation, arguing that "to allow phonology to be powerful enough to account for the quirkiest phoneme alternation is to weaken phonological theory to the point of being unfalsifiable" (Green, 2006, p. 37). He also rejects the concept of a segmentally empty morpheme (or morphophoneme), in the absence of independent evidence. Finally, he asserts that a phonological account cannot explain the vast number of lexical exceptions and irregularities (see Sections 2.4.1 and 2.4.2).

According to Green's alternative analysis, Irish nouns, verbs and adjectives possess three distinct "mutation grades", corresponding to their radical, lenited and eclipsed forms respectively. The triggers of initial consonant mutation are lexically or syntactically marked with a diacritic that requires the words they govern to appear in a particular mutation grade. For example, lenition after *mo* 'my' (environment (A5)) can be explained by assuming that the personal pronoun *mo* contains a diacritic requiring its noun to appear in its lenited form.

Green's theory deals very well with the non-adjacency problem, since it does not require the existence of a silent morpheme moving across the boundary between two words. It also easily accounts for the wide range of irregularities in the data, by proposing that these exceptions are listed in the lexicon, the "natural home" for such idiosyncratic behaviour. However, in removing the mutations from the phonology, Green's theory runs into some difficulties.

By considering ICM as purely morphological, Green's analysis avoids the use of highly idiosyncratic phonological processes. However, Ball & Müller (2002, p. 124) claim that it would be "eccentric" and "inadequate" to declare that phonology does not play any role, since this assumption overlooks the obvious phonological patterns in the data (see Section 2.3). Green defends his approach against these concerns by proposing that the phonological patterns are accounted for in the lexicon through the use of word formation strategies (WFSs), remnants of earlier phonological processes that are deduced by speakers during language acquisition (Ford et al., 1997). However, this approach is still not entirely satisfactory, and has been accused of being "unfalsifiable" (Wolf, 2007).

A more serious problem for Green's theory is the fact that deletion of /*fʲ*/ under lenition leaves a palatal offglide that docks onto a preceeding consonant (see Section 2.5). Under Green's approach the lenition mutation grade for words beginning with /*fʲ*/ would have to contain a floating autosegment with the feature [+palatal], which would bring the mutations back into the realm of phonology.

3.4.2 Pattern extraction and subcategorisation

Green's proposal avoids the phonological question by dismissing it as a remnant of the historical origin of ICM. However, like Ball & Müller (2002), Hannahs (2013) notes that this type of analysis overlooks the broad phonological patterns still present in the phenomenon, and fails to account for the productivity of the phonological patterning in the mutations of non-native segments, borrowings and neologisms. Instead, he proposes a process of "pattern extraction and subcategorisation" whereby initial consonants are associated with their mutated forms in the lexicon.

According to Hannahs, learners of Celtic languages construct specific associations of initial segments by analogy, via a process he calls "pattern extraction". Rather than listing the mutated forms as separate allomorphs, Hannahs suggests that the lexicon contains only the radical form of each word. However, the speaker's knowledge also includes the mutations associated with each initial consonant. For example, to construct the mutated forms of *bróg* 'shoe', the speaker would require two pieces of information from the lexicon:

1. The radical form of the word: /*bro:g*/
2. The pattern associated with word-initial /*b*/: /*b*/ surfaces as [*b*] in radical contexts, [*v*] in lenition contexts and [*m*] in eclipsis contexts

Hannahs suggests that mutations are triggered via a process of subcategorisation. For example, a certain word might require its complement to appear in a particular mutation form, and this information would be listed in the lexical entry for that word, as shown in (14) for *faoi* 'under'.

(14) *faoi*: PREP, [____ $\mathrm{X}_{\langle\text{lenition}\rangle}$ $]_{\mathrm{PP}}$

This process would ensure that the correct mutated form would be selected in the correct environment.

An advantage of Hannahs' theory is that it emphasises the alternations themselves, unlike Green's proposal, which places the focus on the entire word. This allows language users to identify the broad patterns that are obscured by full lexical listing. It also accounts for the participation of neologisms and loanwords in the mutations.[9]

However, there are some serious flaws with Hannahs' theory. Like Green, Hannahs struggles to account for the palatal offglide following deletion of /*fʲ*/. He cannot explain the mutation of /*s*/ to /*t*/ in some lenition environments, nor can he explain why triggering environments sometimes depend on phonology. Once again, we are forced to conclude that ICM cannot be removed entirely from the domain of phonology.

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[9] However, there is a great deal of evidence to suggest that in recent years, Irish loanwards have tended to resist initial consonant mutation (Chudak, 2010; Stenson, 1993).

3.5 Syntax-based approaches

3.5.1 Lexicalised functional heads as mutation triggers

Studies of Irish initial consonant mutation as a syntactic phenomenon have been relatively limited. One major exception to this is the work of Duffield (1995), who claims that Celtic mutation is in fact a "deeply syntactic process". Duffield argues that the traditional view of ICM as an arbitrary lexical property is incorrect, as it misses out on significant generalisations that can be made by adopting a syntactic approach.

Duffield begins by distinguishing two types of mutation, which he terms lexical mutation (L-mutation) and functional mutation (F-mutation). He demonstrates that by making this distinction, the seemingly chaotic phenomenon of ICM can be resolved into a relatively logical system, with some interesting patterns emerging.

According to Duffield, L-mutation is a phonological phenomenon, sensitive primarily to linear structure and phonological properties of its environment. L-mutation can be found in environments (A6-7), (B1-5), (D1), (E1) and (E4) in Tables 4 and 5. F-mutation, found in all remaining mutation environments, is a syntactic phenomenon, under which mutation is triggered by the lexicalisation of a functional head.

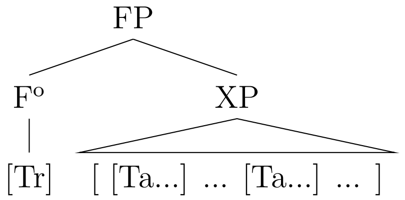
There are several characteristic features that distinguish between L-mutation and F-mutation (Duffield, 1995, pp. 274, 280). L-mutation is always linearly local, meaning that the mutation trigger (Tr) is directly adjacent to the mutation target (Ta) (Figure 9a). In contrast, F-mutation is hierarchically local, giving the trigger scope over all targets within its domain (Figure 9b). F-mutation usually triggers mutation on the leftmost lexical item in its domain, but can 'skip' intervening lexical items or induce mutation on multiple targets in certain situations. For L-mutation, this would be impossible.

Figure 9: Structural properties of lexical and functional mutation

(a) Linear structure of L-mutation:

$$[\ldots\text{Tr}]_\omega\ [\text{Ta}\ldots]_\omega$$

(b) Hierarchical structure of F-mutation:



Another distinguishing feature is that L-mutation often depends on the phonological properties of the trigger, while F-mutation does not. L-mutation is also sensitive to the categorial properties of its lexical target, while F-mutation is not. Compare (15-a) and (15-b) (L-mutation) with (16-a) and (16-b) (F-mutation) (Duffield, 1995, pp. 275-277).

(15) a. *fuinneog* ***mh****ór*
window big
'a big window'

b. *fuinneog measartha/** ***mh****easartha mór*
window fairly big
'a fairly big window'

(16) a. *fonnmhar* [*ar* [***ch****abhair a thabhairt do mhairnéalach*]]
eager on help PRT give.VN to sailor
'eager to help a sailor'

b. *ag argóint* [*faoi* [***ch****éard a ba cheart domhsa a dhéanamh*]]
PROG argue about what PRT COP.PAST right to.1SG PRT do-VN
'arguing about what I should do'

Note that lenition is not triggered on the adverbial modifier in (15-b) (L-mutation), and that its presence blocks lenition of the adjective. In contrast, F-mutation is blind to the categorial properties of its target, inducing mutation on the left-most lexical item in its domain, whether that is a noun (16-a) or an interrogative pronoun (16-b).

Having distinguished between the two types of mutation, Duffield narrows his focus to F-mutation, seeking to provide a unified syntactic account of the phenomenon. Noting that almost every mutation-triggering morpheme is a grammatical particle belonging to the closed-class set, Duffield proposes that F-mutation is a property of lexicalised functional heads.

Duffield (1995, p. 55) begins by stating his mutation hypothesis for finite verbs:

(17) Duffield's Mutation Hypothesis (finite verbs):

a. A lexicalised C^0 node triggers Eclipsis
b. A lexicalised T^0 node triggers Lenition

Using this simple and concise hypothesis, and drawing heavily on the work of McCloskey (1996) in Irish syntax, he succeeds in developing a unified account of the triggering properties of all preverbal particles in Irish. In particular, he manages to accurately predict the correct mutation type for the cases of direct (18-a) and indirect (18-b) relative clauses (environments C4 and G2), by positing that the clause-initial relative particle *a* occupies the T^0 node in the former, and the C^0 node in the latter.

(18) a. *an chabhair*$_{\text{i}}$ [*a* ***th****ugann siad daoibh* t$_{\text{i}}$]
the help PRT give.PRES.L they to.2PL ∅
'the help that they gave you'

b. *an chabhair* [*a* ***dt**ugann* *siad daoibh í*]
the help PRT give.PRES.E they to.2PL it
‘the help that they gave you’ (lit. ‘the help that they gave it to you’)

He then extends this hypothesis to the case of head-nouns following the definite determiner *an* (a lexicalised D^0 node) or a preposition (a lexicalised P^0 node). In doing so, he manages to explain a large number of the irregularities listed in Tables 4 and 5.

The greatest strength of Duffield’s syntactic approach is that it provides a unified account of almost all the F-mutation environments, employing one simple hypothesis to explain many of the idiosyncrasies in the data. It also deals well with the non-adjacency problem. However, Duffield provides very little analysis of the grammatical mechanism of L-mutation, and offers no justification for the particular phonological alternations observed in Irish.

3.6 An integrated approach to mutation

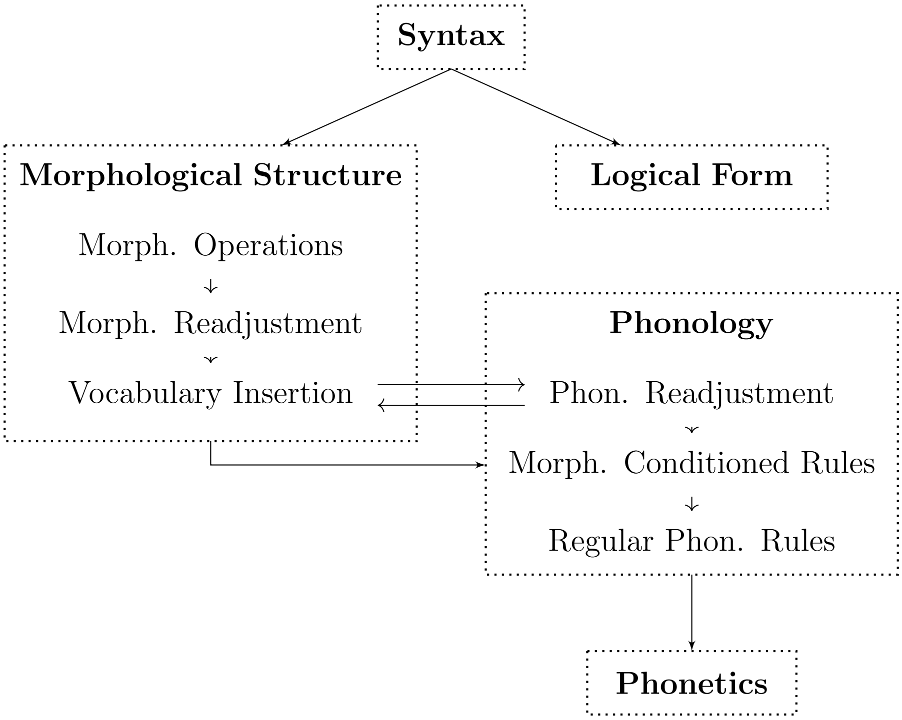
Pyatt (1997) constructs a derivational model of ICM, which takes mutations from the underlying syntactic structure through to the surface phonology. She achieves this within the framework of Distributed Morphology (Halle & Marantz, 1993).

Figure 10 gives a schematic representation of the operations that take a word from its underlying representation to its output form, according to Distributed Morphology (DM). This is a derivational model, meaning that operations are applied sequentially; beginning with the syntax, followed by the morphological structure and phonology, and finally the phonetics. Most crucially for ICM, DM proposes the existence of a cyclic phase between “vocabulary insertion” and “phonological readjustment”, during which the grammar has access to both morphological and phonological information.

DM assumes that each morpheme is listed under a phonological index which is associated with several morphosyntactic features, including semantic meaning, head type, argument structure, gender, etc. Pyatt proposes that mutation triggering features are listed in the form of a diacritic, which she defines as “a morphosyntactic feature whose sole information content is designating a phonological index as the trigger of a phonological readjustment or a morphologically conditioned phonological rule” (Pyatt, 1997, p. 101). The diacritic is applied during the “phonological readjustment” phase of the grammar, and allows for more precision than a floating feature explanation would. To see how this works, consider the example below (adapted from Pyatt (1997, pp. 124-127)), in which lenition is triggered after the preposition *roimh* ‘before’ (environment (A8)).

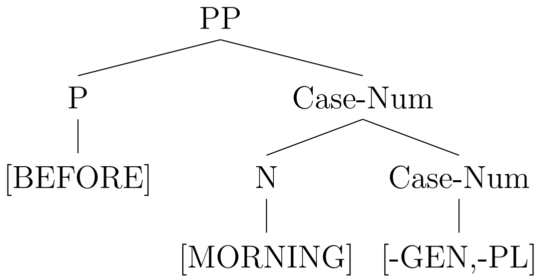
(19) *roimh* ***mh**aidin*
before morning.L
‘before morning’

Figure 10: Schematic representation of operations in Distributed Morphology



The structure of the prepositional phrase is given in Figure 11, while the relevant lexical entries are given in (20).

Figure 11: Structure of an Irish prepositional phrase in Distributed Morphology



(20) a. */rivʲ/* – [BEFORE, P^0, {L}] = *roimh* ‘before’
b. */madʲənʲ/* – [MORNING, N^0, F] = *maidin* ‘morning’
c. ∅ – [Case-Num, -GEN, -PL]

After “vocabulary insertion” but before “phonological readjustment”, the phonological indices listed in (20) have been inserted, but the mutation has not yet occurred. At “phonological readjustment”, the {L} diacritic of the preposition *roimh* ‘before’ triggers mutation, according to the readjustment rule given in (21).

(21) Lenition of */m/* - Readjustment Rule:
$m \rightarrow v$ / M–[{L}] [#____

In other words, a morpheme marked with a {L} diacritic appearing directly before a */m/*-initial word will cause that */m/* to mutate to */v/*.

Of course, the lenition of */m/* to */v/* is only one of a number of distinct consonant changes in lenition environments (see Table 2). Pyatt argues against the treatment of such "complex mutation" as a single phonological process, instead considering it as an ordered list of phonological rules triggered by one diacritic (Pyatt, 1997, pp. 255-256):

(22) Lenition Readjustment Rules:
i. *f(ʲ) → ∅* / M–[{L}] [#___
ii. *s, ʃ → h(ʲ)*
iii. *m(ʲ) → v(ʲ)*
iv. [+cons, +son] → [-back]
v. [-son] → [+cont]

Note that this list does not include the "repair rules" that transform the ungrammatical */ð/ to /ɣ/ – such rules are applied at a later stage in the grammar (cf. Section 3.3).

The advantages of Pyatt's approach are manifold. Her theory deals exceptionally well with irregularities in the data (including lenition of */s/* to */t/* in some lenition environments), without overlooking important generalisations. It also provides an elegant explanation for syncretism in mutation – that is, morphemes that differ only in the type of mutation triggered (c.f. examples (1) and (2) in Section 2.4).

On the other hand, the theory is poor at handling situations in which trigger and target are non-adjacent, nor can it account for triggering environments that depend on phonology. Furthermore, the involvement of abstractions such as diacritics makes Pyatt's solution complex and difficult to verify.

3.7 General comments

The theories proposed in this chapter highlight some of the difficulties associated with the phenomenon of ICM, and explore a variety of different ways for dealing with these difficulties. However, it is clear that no single theory has yet been put forward that can account for the full range of data presented in Section 2.

The phonology-based approaches (Section 3.3) focus on the characterisation and representation of the phonological alternations observed in Irish initial consonants. Ó Dochartaigh (1979) and Ní Chiosáin (1991) make use of rule-based accounts that capture the spirantisation and debuccalisation properties of lenition environments. Both theories can explain the origin of the palatal offglide following deletion of */fʲ/*, and Ní Chiosáin also addresses the issue of mutation blocking. Swingle (1993) takes an affixational approach. While he cannot explain the deletion of */f/*, he manages to unify the remaining lenition alternations by using a single lenition prefix.

These approaches are clearly successful at dealing with the phonological aspects of ICM (problems (i)-(iv) in Table 6). However, they tend to ignore the question of how the mutations arise in the first place. The morphology- and syntax-based approaches primarily aim to address this question.

Green (2006) and Hannahs (2013) take a morphological approach, whereby mutated forms are chosen in a parallel manner to case selection in Latin or Russian (Section 3.4). Green lists entire mutated forms as allomorphs in the lexicon, while Hannahs attempts to capture the broad phonological patterns by associating initial consonants with their mutated forms in the lexicon. Both theories deal well with the issue of non-adjacency (problem (vi) in Table 6), but they cannot account for triggering environments that depend on phonology (problem (v)). They also struggle to explain the palatal offglide effect following deletion of /fʲ/.

Duffield (1995) takes a syntactic approach, demonstrating that significant generalisations that can be made in doing so (Section 3.5). His theory elegantly unifies a certain subset of the triggering environments (which he terms F-mutation); however, it provides almost no explanation for the remainder, and makes no reference at all to the source of the phonological alternations.

Of the approaches reviewed, Pyatt (1997) is the most successful at involving all elements of the grammar (Section 3.6). Her derivational model takes mutations from the underlying syntactic structure through to the surface phonology, using a morphosyntactic diacritic to carry information between modules. By treating mutation as an integrated phenomenon, she accounts for both the triggering process and the phonological alternations.

The primary criticism against Pyatt's approach is its use of diacritics, despite there being no independent evidence for such abstractions. Kiparsky (1982) has argued against the use of abstract underlying segments, stating that they should be excluded from the grammar altogether wherever possible. However, others have insisted that abstractions are valuable, and indeed necessary, for providing an adequate description of language (Hyman, 1970; Selkirk & Vergnaud, 1973). Hyman notes that the aim of grammar is not only to find neater ways to present data, but also to understand the underlying mental mechanism employed during language acquisition. Given this, a diacritic could be thought of as a way to capture a part of the abstract knowledge gained by speakers as they navigate the complex patterns in their native language. Therefore, the use of diacritics and other abstractions may be justified if it manages to capture broad patterns in the data.

4 Optimality Theory

4.1 Introduction to Optimality Theory

Optimality Theory (OT) was first introduced by Prince & Smolensky (1993) as an alternative to traditional rule-based models of theoretical linguistics. It began in the domain of phonology, but has since spread to other domains, including morphology, syntax, language acquisition and change (Archangeli, 1999). The fundamental hypothesis is that linguistic phenomena can be entirely accounted for by a set of universal constraints, without resorting to language-specific rules.

Modern linguistics generally takes the view of Chomsky (1965) that humans are genetically predisposed to learn language, possessing an internal "universal grammar" (UG). The aim of linguistic theory is therefore to develop a theory of UG that predicts accurately and concisely which grammars are permitted in natural language, and which are not. In particular, this involves providing an explanation for both the cross-linguistic similarities and the typological differences observed in the world's languages.

Optimality Theory provides a powerful way of achieving these goals. According to OT, cross-linguistic similarities are simply a manifestation of a set of universal constraints that apply to all natural languages. However, differences between languages arise due to the violable nature of these constraints. In particular, the language-specific part of the grammar is encoded in the specific ranking of constraints, which is unique to each language. In this way, OT manages to capture linguistic universals, while still accounting for the wide variation in natural language (Archangeli, 1997).

4.2 The structure of Optimality Theory

In OT, one must distinguish between universal grammar (UG), which is common to all languages; and language-specific grammar (LG), which is unique to the particular language under investigation. According to OT, UG has three distinct elements (Archangeli, 1999, p. 534):

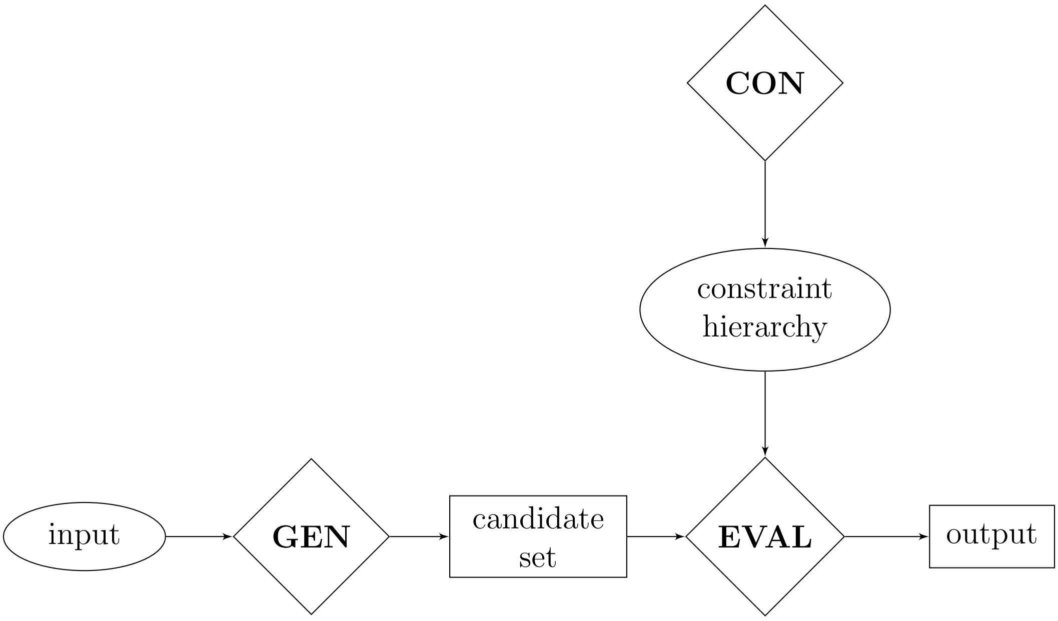
- **GEN:** A function for generating relationships between a given input form and all potential output forms
- **CON:** A universal set of constraints on possible output forms
- **EVAL:** A function for evaluating the outputs against a set of ranked constraints, in order to select the optimal output for a given input

These grammatical elements are universal, meaning that the functions GEN and EVAL, and the set of constraints CON, are identical for all of the world's languages.
The language-specific grammar has two principal elements:

- A set of input forms
- A ranking of the set of constraints in CON, known as the constraint hierarchy

The output form is determined as a result of interaction between the elements of UG and LG listed above. Figure 12, adapted from Archangeli (1999, p. 534) gives a schematic representation of this process.

Figure 12: Schematic representation of grammar in Optimality Theory



Key: oval = language-specific grammar (LG); diamond = universal grammar (UG); box = derived by interaction between LG and UG

As shown in Figure 12, the universal set of constraints (CON) is ranked to form a constraint hierarchy, which is language-specific. Upon encountering an input form, the generating function (GEN) produces a candidate set of output forms. This set is entered into the evaluating function (EVAL), which uses the constraint hierarchy to determine the optimal output form.

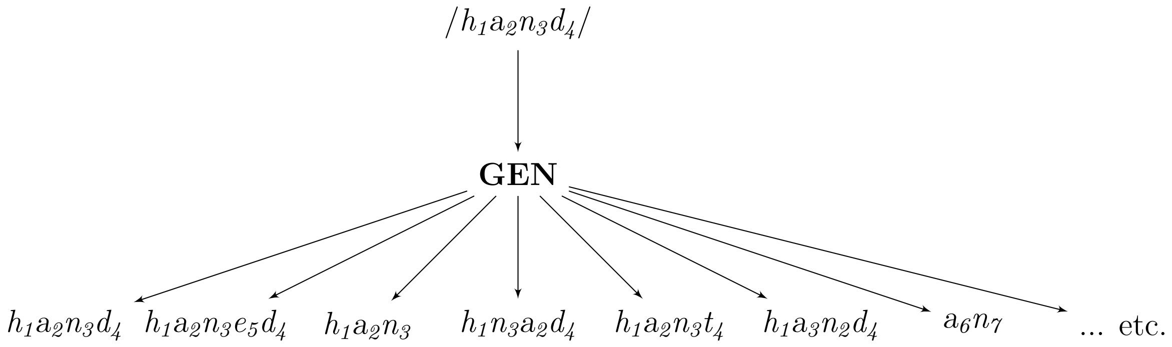
It is clear that possible output forms permitted in natural language depend crucially on the nature of the constraints in CON. However, before exploring the major constraint families, the mechanisms of GEN and EVAL will be discussed in more detail.

4.2.1 The generating function (GEN)

The purpose of GEN is to produce a candidate set for every input, along with correspondences between the input and output forms. In the conventional formulation, GEN may add, delete, rearrange or alter the features of phonological segments without restriction (Archangeli, 1997, p. 14). It may also shuffle the correspondences between segments. This results in a potentially infinite set of possible output forms for any given input.

For example, consider the input form $/h_1a_2n_3d_4/$ (see Figure 13).[10] The operations performed by GEN include adding a segment ($h_1a_2n_3e_5d_4$), deleting a segment ($h_1a_2n_3$), rearranging segments ($h_1n_3a_2d_4$), altering the features of a segment ($h_1a_2n_3t_4$), shuffling correspondences between segments ($h_1a_3n_2d_4$), or even removing all correspondences between the output and input forms (a_6n_7). By performing combinations of these operations, GEN generates an infinite candidate set of output forms corresponding to the input $/h_1a_2n_3d_4/$.

Figure 13: Action of GEN on input */hand/*



The generation of such an infinite set poses problems for the implementation of OT, particularly for psycholinguistic and computational models of language. This issue is addressed by Heiberg (1999), who has developed an algorithm that deals with the problem of infinite output generation by placing reasonable restrictions on candidates.

4.2.2 The evaluation function (EVAL)

EVAL is the mechanism by which an optimal candidate is selected from the candidate set created by GEN. It does this by considering the ranking of constraints (constraint hierarchy) particular to the language under investigation. Two criteria are used to determine the candidate that best satisfies the ranked constraints (Archangeli, 1997, p. 14):

- Violation of a lower ranked constraint may be tolerated in order to satisfy a higher ranked constraint.
- Ties (by violation or by satisfaction) of a higher ranked constraint are resolved by a lower ranked constraint.

OT research uses a device called a *tableau* to show that a given constraint ranking leads to the selection of an optimal output form (to be demonstrated in Section 4.4).

---

[10] The subscripts are used to indicate correspondences between input and output forms.

4.3 Major constraint families in OT

The universal constraint set (CON) is the formal means by which linguistic universals are encoded. In other words, CON is assumed to represent a crucial part of our innate knowledge of language. This section will explore some of the core constraint families in OT.

4.3.1 Faithfulness constraints

Faithfulness constraints (Faith) capture the fact that the mental representation (input) and surface representation (output) are usually more or less identical to one another (Archangeli, 1999). Such constraints require correspondence between the input and output forms. There are two principal subfamilies of faithfulness constraints:

- Max (maximise the input): Requires that every segment/feature in the input has an identical correspondent in the output
- Dep (output depends on the input): Requires that every segment/feature in the output has an identical correspondent in the input

For example, given the input $/h_1a_2n_3d_4/$ (see Figure 13 in Section 4.2.1), Max would filter out forms such as $[h_1a_2n_3]$, which does not contain a segment corresponding to the input segment $/d_4/$; while Dep would filter out forms such as $[h_1a_2n_3e_5d_4]$, which contains a segment ($[e_5]$) that does not exist in the input.

Clearly, if CON contained only faithfulness constraints, the input would always be identical to the output, and there would be no role for the grammar at all in deriving the surface form. Additional types of constraint are required in order to account for the alternations and variations found in natural language.

4.3.2 Syntagmatic constraints

Syntagmatic constraints impose restrictions on possible sequences of sounds in the output form (Pulleyblank, 1997, p. 64). They do this by requiring sequences of segments to possess particular featural properties. For example, a syntagmatic constraint might require adjacent consonants to be identical in voicing, place of articulation or continuancy. The function of these so-called Syntagmatic Identity (S-Ident) constraints is to impose articulatory inertia. In English, for instance, the constraint S-Ident(Place), which requires adjacent consonants to be identical in place of articulation, is responsible for transforming the input */in/* + */perfect/* to an output form */i**m**perfect/*. Note that in this example, the input alveolar nasal stop becomes a bilabial nasal stop in the output, suggesting that in English, S-Ident(Place) is ranked higher than Faith(Place).

4.3.3 Alignment constraints

Alignment constraints require that the edges of two categories (morphological, phonological or prosodic) match (McCarthy & Prince, 1994, p. 5). Constraints in this family are usually formalised as ALIGN(CAT1, EDGE1; CAT2, EDGE2), where CAT1 and CAT2 refer to phonological or morphological categories, and EDGE1 and EDGE2 are either "left" or "right", referring to the respective edges of these categories.

One important thing to note is that ALIGN is not technically a constraint, but rather a schema for creating constraints (K. Russell, 1997, p. 119). This means that alignment constraints which appear in a language's constraint hierarchy are not necessarily universal (although the schema itself is). However, the wide scope of this "Generalised Alignment", encompassing both morphology and phonology, makes it a powerful tool for expressing interactions between grammatical modules, something that is crucial in the study of ICM (see Section 5).

4.3.4 Markedness constraints

Markedness constraints come in two types, either demanding unmarked structures or prohibiting marked ones. For example, consider the following universal constraints on syllable structure (Archangeli, 1997, p. 7):

- ONSET: Syllables begin with a consonant
- PEAK: Syllables have one vowel
- NOCODA: Syllables end with a vowel (i.e. they do not have a "coda", or syllable-final consonant)
- *COMPLEX: Syllables have at most one consonant at an edge (i.e. they do not contain a "complex" cluster of consonants)

The first two constraints demand unmarked structures, while the latter two prohibit marked ones.

Markedness constraints can be used to account for universal typological trends in languages. For example, the collection of constraints listed above can explain the prevalence of CV as the most common type of syllable structure in the world's languages.

First, note that the CV syllable structure is the only one that satisfies all four constraints – this accounts for the universality of CV syllables cross-linguistically. On the other hand, the existence of other, more marked syllable structures can be attributed to the violability of these constraints, and in particular their relative rankings in the constraint hierarchy of a given language. Table 8 demonstrates how permitted syllable structures depend on the rankings of ONSET, NOCODA and FAITH (Archangeli, 1999, p. 537).

Table 8: Syllable typology in Optimality Theory

	Onset ≫ Faith	Faith ≫ Onset
NoCoda ≫ Faith	CV (e.g. Hua)	CV, V (e.g. Hawaian)
Faith ≫ NoCoda	CV, CVC (e.g. Cairene)	CV, V, CVC, VC (e.g. Mokilese)

One important thing to note is that, unlike the previous three constraint types, markedness constraints do not have a rigorously defined general form (Archangeli, 1999, p. 547). Instead, constraints fall into this class if they in some way characterise cross-linguistic tendencies.

4.4 A simple example

Consider the following example, involving a comparison between English and Dutch. Coda obstruents are devoiced in Dutch, as seen in (23) below (Kager, 1999, p. 14).

(23) a. /*bɛd*/ [*bɛt*] ‘bed’
b. /*bɛd-ən*/ [*bɛ.dən*] ‘beds’

In English, on the other hand, codas do not follow this restriction. Thus the /*d*/ in an input /*bɛd*/ is voiced in all cases:

(24) a. /*bɛd*/ [*bɛd*] ‘bed’
b. /*bɛd-iŋ*/ [*bɛ.diŋ*] ‘bedding’

Note that the underlying forms in (23-a) and (24-a) are identical – the difference in surface form is entirely a result of some language-specific process.

Optimality Theory provides a clear and logical explanation for this observation. According to OT, the different surface forms arise as a result of an interaction between two conflicting constraints. The first is a faithfulness constraint, requiring that the input value of the feature [voice] be preserved in the output:

(25) Faith(Voice): The specification for the feature [voice] of an input segment must be preserved in its output correspondent.

The second constraint is a markedness constraint, prohibiting voiced obstruents in a syllable coda:

(26) *V-Coda: Obstruents must not be voiced in coda position.

Recall that in OT, these constraints are universal; however their effect depends on their relative positions in the constraint hierarchy of a language. In Dutch, the output form satisfies *V-Coda, but violates Faith(Voice). This suggests the following constraint ranking in Dutch:

(27) Coda devoicing in Dutch:
*V-Coda ≫ Faith(Voice)

With this ranking, the correct optimal candidate is selected for Dutch. To see this, consider the following OT tableau (Table 9). Constraints are listed along the top (ordered by the constraint hierarchy of Dutch), and candidate forms are listed along the left-hand side. Violations of constraints are represented by an asterisk in the relevant cell, while fatal violations (i.e. violations of the highest relevant constraint) are represented by an exclamation mark. The last candidate to trigger a fatal violation is selected as the optimal candidate; in this case, it is candidate a.

Table 9: Tableau for the input /*bɛd*/, assuming the Dutch ranking

/bɛd/	*V-Coda	Faith(Voice)
☞ a. [bɛt]		*
b. [bɛd]	*!	

In English, the output form satisfies Faith(Voice), but violates *V-Coda. This suggests the following constraint ranking in English:

(28) Preservation of voicing contrast in English:
Faith(Voice) ≫ *V-Coda

With this ranking, the correct optimal candidate is selected for English (Table 10).

Table 10: Tableau for the input /*bɛd*/, assuming the English ranking

/bɛd/	Faith(Voice)	*V-Coda
a. [bɛt]	*!	
☞ b. [bɛd]		*

The important thing to learn from this example is that both languages possess the same universal constraints, and differ only in how these constraints are ranked. Reorderings of constraints in this manner can be used to predict a large number of cross-linguistic phenomena, without resorting to language-specific rules.

Our example compared words from two separate languages, but the logic could equally well be applied to two dialects of the same language. In OT, language variation and change is accounted for by the rearranging of constraints over time, particularly when the evidence for a particular ranking is not very robust (Archangeli, 1997, p. 31). We shall see later that this idea could be used to explain some of the dialectal variation in Irish ICM discussed in Section 2.6.

4.5 Optimality Theory and interface problems

The structure of Optimality Theory lends itself particularly well to interface phenomena, that is, phenomena that involve more than one component of the grammar. This is because, although the theory was originally developed with phonology in mind, it is not intrinsically specialised to deal with phonological processes. In fact, OT allows for the possibility of constraints from all modules of the grammar, and most crucially, allows constraints from different modules to be evaluated together. However, the involvement of other grammatical modules does raise some important questions about the nature of the input, candidate set and constraints, some of which will be explored here.

4.5.1 Input and candidate set

To extend OT to non-phonological grammatical components, one must re-examine what forms are permitted in the input, and what operations GEN may use to generate the candidate set. It is no longer sufficient to consider only the underlying phonological representation; the scope must be extended to include morphosyntactic information too.

For example, in the case of phonologically-conditioned allomorphy, the conventional OT approach is to allow the input to list multiple allomorphs; these allomorphs are then evaluated against each other (Lapointe, 2001). Thus, for example, in order to derive the accusative form of *cho* in Korean, the input would consist of the stem *cho* and the two accusative allomorphs {*-ul*, *-lul*} (Xu, 2016). Table 11a demonstrates how the correct ending is selected, with reference to the markedness constraints on syllable structure introduced in Section 4.3.4.

However, this approach does not work in all cases. Xu (2016) demonstrates that it fails to predict the cross-linguistically observed asymmetry between stem-conditioned affix allomorphy and affix-conditioned stem allomorphy. Furthermore, it does not account for the observed sensitivity to the phonological properties of the underlying form.

Because of this, alternative approaches must be considered. One such approach is the theory of “Optimal Interleaving” (OI) (Wolf, 2008). Returning to the Korean example, the input now consists of the stem *cho* and the morphosyntactic feature value {acc}, while the allomorphs are added by GEN. An additional constraint, MAX-M(F), requires that every abstract morphosyntactic feature value in an input should have a correspondent in the feature set of a lexical item in the output. This approach avoids the problems raised by Xu, while still predicting the correct output form (Table 11b).

Another approach is Realization OT (Xu & Aronoff, 2011). Here, the input is the same as in OI, but the allomorphs are listed in CON rather than being added by GEN. This approach undermines the universality of the constraint set, but is better at dealing with issues such as blocking and syncretism. Table 11c demonstrates how this works for the Korean example.

Table 11: Tableaux for Korean accusative allomorphy

(a) Conventional OT

cho, {-ul, -lul}	Onset	NoCoda
☞ a. cho.lul		*
b. cho.ul	*!	*

(b) Optimal Interleaving

cho, {acc}	Max-M(F)	Onset	NoCoda
☞ a. cho.lul			*
b. cho.ul		*!	*
c. cho, {acc}	*!		

(c) Realization OT

cho, {acc}	{acc:-lul}	{acc:-ul}	Onset	NoCoda
☞ a. cho lul-{acc}		*		*
b. cho ul-{acc}	*		*!	*
c. cho, {acc}	*	*!		

4.5.2 The form of the constraint hierarchy

The last section discussed how incorporating morphology into OT affects the input and candidate set. Here we will look at the effects of interface phenomena on the constraint hierarchy of a language.

A certain class of interface phenomena arises when different phonological rules apply depending on the morphological or syntactic context. For example, it has been observed that a number of languages permit nouns to show more phonological contrast than other word classes (Smith, 1997). Such morphologically-conditioned phonology has been approached in two ways. The first is to posit interface constraints that rank faithfulness for nouns in a higher position than faithfulness for other word classes (Example (29)).

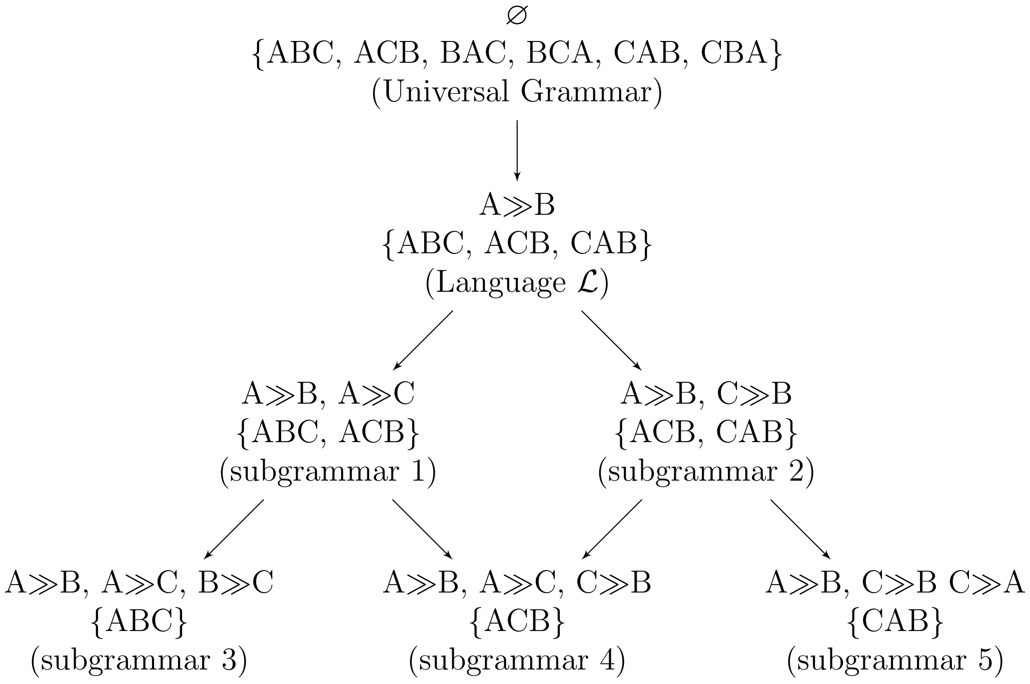
(29) Typical interface constraint:
Faith$_{noun}$ ≫ Mark ≫ Faith

The alternative is to keep phonological constraints purely phonological, but to posit a separate list of constraints (cophonology) for different morphological categories (Example (30)).

(30) Cophonologies:
a. Faith ≫ Mark (nouns)
b. Mark ≫ Faith (other words)

Anttila (2002) notes that the cophonology interpretation is compatible with the idea of a partial order of constraints. Unlike in a total order, the constraint ranking in a partial order may be incomplete (Partee et al., 1990, pp. 207-212). Anttila suggests that grammars are partial orderings of OT constraints, and that sub-regularities in the language arise as a result of different sub-orderings. Figure 14 (Anttila, 2002, p. 22) demonstrates how a collection of such "subgrammars" are simultaneously compatible with a partially ordered grammar $\mathcal{L}$.

Figure 14: Possible subgrammars for imaginary constraints {A, B, C}



4.5.3 Parallel evaluation of sub-representations

K. Russell (1999) brings a novel perspective to interface problems in OT. He notes that most work in OT has implicitly adopted what he calls the "assembly line view" of the overall structure of language (Figure 15). Although a non-derivational approach is applied within individual modules, the relationship between modules is taken to be linear and directional. For example, in Tables 11a–11c, it is assumed that the correct phonological form has been derived for the root *cho* via a phonology tableau; this output has then been re-entered into the morphology tableau in order to select the correct accusative form.

Figure 15: An assembly line view of language

Russell rejects the assembly-line view, instead proposing that all modules of the grammar are evaluated together. In his theory of MOT[11], a complete linguistic representation consists of at least three sub-representations, one each for phonological, syntactic and semantic information:

(31) ⟨ Ph, Sy, Se ⟩

The function of the grammar is to look at a complete representation and judge whether or not it is a legal structure in the language. Thus in MOT, all modules of the grammars are evaluated simultaneously, and there is no underlying representation or input form.

For example, consider the following representations for the single-word utterance *teacups* in English.

(32) a. ⟨ [*tiː.kʌps*], [N^0, PL], ☕☕☕... ⟩
b. ⟨ [*tiː.bægz*], [N^0, PL], ☕☕☕... ⟩
c. ⟨ [*tiː.kʌps*], [N^0, SG], ☕☕☕... ⟩
d. ⟨ [*tiː.kʌps*], [N^0, PL], ☕⟩
e. ⟨ [*tiː.kʌps*], [N^0, PL], ⚽⚽⚽... ⟩

Representation (32-a) is legal in English because each of its sub-representations is optimal, given the other two. In other words, it is the optimal representation out of an infinite number of candidates that are identical to it, except with a different Ph (32-b), Sy (32-c), or Se (32-d)/(32-e).

In MOT, interface constraints are used to ensure that the correct sub-representations co-occur with each other. These could be universal violable constraints, as expected in OT (e.g. "an object in Se corresponds to a nominal in Sy"). However, MOT also claims that lexical entries themselves are a type of interface constraint (e.g. "the concept of 'teacups' in Se corresponds to a representation [*tiː.kʌps*] in Ph").

The advantages of Russell's approach in the area of interface phenomena are clear. By evaluating constraints from all modules of the grammar in parallel, such phenomena can be analysed with no more difficulty than phenomena restricted to a single module. However, this benefit comes at a cost. Without an underlying form, there is no place for the faithfulness constraints that underpin much of traditional OT, and this can lead to serious problems elsewhere. In addition, the universality of CON is sacrificed when language-specific lexical entries are included as constraints. Nevertheless, Russell's theory offers some interesting new perspectives on OT, and on interface phenomena in particular.

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[11] The letters "MOT" stand for "absolutely nothing"; Russell reluctantly named his theory MOT after being told that "any new proposal needs a flashy acronym in order to be accepted" (K. Russell, 1999, p. 11).

5 An Optimality Theory Approach to ICM

5.1 The case for an Optimality Theory approach

Having introduced Optimality Theory as a general model of language, we now return to the problem of initial consonant mutation.

It should be clear that ICM is a complex and multifaceted phenomenon, occurring at the interface of phonology, morphology and syntax. As seen in Section 3, most theoretical accounts of ICM thus far have focused on just one of these grammatical modules, prioritising either the triggering mechanism or the phonology of the alternations (but not both). The exception to this is Pyatt's derivational approach (Pyatt, 1997), which provides an integrated account of mutation within the framework of Distributed Morphology (see Section 3.6). Of the theories reviewed (Section 3), this is the most successful at accounting for all aspects of ICM.

However, there are several problems with the derivational approach. Most serious is the issue of constraints (Archangeli, 1997, p. 26). Constraints are found at every stage of the derivational model – for example, they restrict what sounds are permitted in underlying forms, they limit how rules can apply, and they prohibit certain patterns in the outputs. The problem is that these constraints are viewed as inviolable, and it is extremely difficult to find a constraint that is never violated across the world's languages.

Furthermore, the derivational approach aims to describe linguistic phenomena in as few rules as possible – the fewer the rules, the better the analysis. Taking this view to its logical conclusion, the simplest grammar would be one in which there are no rules, and all inputs are identical to their outputs (Pulleyblank, 1997, p. 63). However, no such grammar has been found, and derivational theories have no way of accounting for this seemingly unavoidable complexity found in natural language.

OT addresses these issues by defining a clear and limited role for constraints: constraints are universal and violable, and language variability arises through language-specific constraint hierarchies. In shifting the focus from language-specific rules to universal constraints, it eliminates rules from the grammar entirely.

In addition to this, OT allows constraints from different modules of the grammar to be evaluated together, making it uniquely suited to interface phenomena such as ICM (see Section 4.5). An OT approach to ICM has the advantage of being able to assimilate into a more general theory of grammar, without resorting to ad hoc rules or processes.

5.2 Phonology of mutations in OT

Because OT was originally formulated as a theory of phonology, it is perhaps unsurprising that the phonology of Irish mutations has been studied within this framework already (Wolf, 2008; Gnanadesikan, 1997). However, both attempts have focused primarily on eclipsis, and neither have succeeded in producing an explicit model to account for all the data. This section will develop a comprehensive theory for the phonology of Irish mutations, and demonstrate some of the advantages gained by the OT approach.

5.2.1 Phonological constraints

Section 3.3 introduced two perspectives on the phonology of mutation – the rule-based approach (Ó Dochartaigh, 1979; Ní Chiosáin, 1991) and the affixational approach (Swingle, 1993). Because rule-based approaches are derivational by nature, they are incompatible with OT; for this reason, we take the affixational approach here. Mutations are assumed to arise as a result of "mutation morphemes", each of which has two allomorphs:

(33) a. Lenition allomorphs:
$\boldsymbol{L} = \{$ [+cont][-cor]; $\varnothing$ $\}$
b. Eclipsis allomorphs:
$\boldsymbol{E} = \{$ [+voi]; [+nas] $\}$

With the exception of the "$\varnothing$" lenition allomorph (to be dealt with later), the mutation allomorphs in (33) consist of sets of floating features. Mutation arises as a result of affixation of these floating features to the initial consonant of the target word. To ensure that the features dock onto initial consonants only, the following alignment constraint is assumed to rank highly in the constraint hierarchy:

(34) Alignment of mutation affixes with initial consonants:
ALIGN($\boldsymbol{L}/\boldsymbol{E}$, LEFT, ω, LEFT)

To enforce the phonological realisation of mutation morphemes in the output, the following constraint is used:

(35) Morpheme Realisation:
MREAL: Every morpheme must be realised in an overt and detectable manner

A more precise definition is provided by Gnanadesikan (1997, p. 94), but roughly speaking, this constraint requires that the affixed form of a word should contain some surface segment/feature that corresponds to a segment/feature in the affix, and is not present in the unaffixed form of the word.

The specific alternations observed in Irish mutation are a result of interaction between MREAL and a selection of other universal constraints, mostly from the faithfulness and markedness families. The relevant constraints are listed in Table 12, ordered according to the proposed constraint hierarchy for Modern Irish (a dotted line indicates that neither constraint crucially outranks the other).

Table 12: Phonological constraints for Irish mutation

Constraint:	**Effect:**
*ɦ, *z	Prohibits certain marked voiced segments
*ṽ, *w̃, *s̃, *f̃	Prohibits certain marked nasalised segments
*m̥, *n̥, *ŋ̊	Prohibits certain marked voiceless segments
Ident(Son)	Requires that if a segment contains the feature [+son] in the input, that segment remains entirely unchanged in the output
Dep(Voi)	Requires that every instance of the feature [±voi] in the output has an identical correspondent in the input
Dep(Nas)	Requires that every instance of the feature [±nasal] in the output has an identical correspondent in the input
MReal	Defined in (35) above
MaxFlt	Requires that all autosegments floating in the input have output correspondents (Wolf, 2008, p. 2)
Faith(Voi)	Requires that the feature value of [voice] in an output segment is identical to that of the corresponding input segment
*Del	Prohibits deletion of input segments in the output
Faith(Dor)	Requires that the feature value of [dorsal] in an output segment is identical to that of the corresponding input segment
Faith(Nas)	Requires that the feature value of [nasal] in an output segment is identical to that of the corresponding input segment
Faith(Cor)	Requires that the feature value of [coronal] in an output segment is identical to that of the corresponding input segment
Faith(Cont)	Requires that the feature value of [continuant] in an output segment is identical to that of the corresponding input segment

Note the distinction between Faith and Ident constraints (as defined here), with the former requiring a feature to remain unchanged and the latter requiring an entire segment to remain unchanged. Ident(Son) is included to account for the fact that the sonorant consonants of Irish (*/n, r, l/*) remain unchanged under both lenition and eclipsis, and are therefore assumed to obey a higher level of faithfulness than other consonants. Note that */m/* is not considered to be a sonorant in Modern Irish; arguments for this view can be found in Ní Chiosáin (1991, p. 48) and Swingle (1993, p. 457).

5.2.2 Phonology of eclipsis in OT

Now that we have introduced the constraints, we may turn to the phonological processes of mutation. In this analysis it is assumed that all Irish consonants are fully specified for all relevant features, unless otherwise stated.

We will begin with the phonology of eclipsis. Recall that eclipsis is triggered by one of the two eclipsis allomorphs, which consist of the floating features [+voi] and [+nas] respectively (Definition (33-b) above).

Tables 13a–13e present OT tableaux covering the mutation of all Irish initial consonants under eclipsis. In each tableau, only the constraints that directly affect the outcome are listed; however, the full set of constraints from Table 12 are assumed to be present in all cases. In examples for which a number of consonants are grouped together, a representative consonant is chosen to illustrate the process (Tables 13a–13d).

The key constraint in each case is MReal, defined in (35) above, which ensures that the eclipsis morpheme triggers some detectable change in the output form. In other words, it requires that the output form contains a realisation of either [+voi] or [+nas] that would not be present otherwise.

For the voiceless consonants /*p, t, k, f*/ (Table 13a), either one of the two eclipsis allomorphs will satisfy MReal, since the input form is [-voi] and [-nas]. The [+nas] allomorph is eventually eliminated, because voiceless nasals are prohibited in Irish, and a voiced nasal would violate Dep(Voi) by introducing a [+voi] that has no correspondent in the input. Therefore, the allomorph [+voi] is selected to produce the optimal candidate.

For the voiced consonants /*b, d, g*/ (Table 13b), only [+nas] will satisfy MReal, because the input is already specified as [+voi].

For the nasal consonants /*m, n*/ (Table 13c), neither allomorph can affect a detectable change on the output, since the input form contains both [+voi] and [+nas]. For this reason, MReal cannot be satisfied by any candidate, and the output remains unchanged. Alternative candidates are ruled out by dependency constraints.

The constraint Ident(Son) requires that the liquids /*r, l*/ remain entirely unchanged from their input form; for this reason they do not undergo eclipsis (Table 13d).

Finally, the exceptional case of the voiceless alveolar fricative /*s*/ (Table 13e) is explained by the presence of markedness constraints **z* and **s̃*, which prohibit the changes that would otherwise apply to /*s*/ under the eclipsis morpheme.

The system described here differs in several ways from past approaches to the phonology of eclipsis in OT. Wolf (2008) does not employ the MReal constraint, but instead uses a combination of MaxFlt and a constraint he calls NoVacDoc to effect the eclipsis mutations. NoVacDoc requires that "floating features cannot dock onto segments that already bore the same feature value in the input" (Wolf, 2008, p. 2). Through this combination of constraints, Wolf ensures that all floating features are docked onto the initial consonant, and that they are not docked "vacuously" (i.e. they must create a detectable change). Faithfulness constraints then ensure that one and only one featural change is made in the output (thus eliminating, for example, the change /*p*/→/*m*/).

Wolf argues that his approach is better at dealing with cases in which mutation changes multiple features, or in which the mutation-triggering morpheme has segmental content (Wolf, 2008, p. 14–18). However, I opted to use MReal in my analysis instead of the MaxFlt/NoVacDoc combination for two reasons. Firstly, Wolf's approach

Table 13: Tableaux for phonology of eclipsis in Irish

(a) Voiceless consonants /*p, t, k, f*/

$\{[+\text{voi}]_1; [+\text{nas}]_2\}+/p/$	*m̥	Dep(Voi)	MReal	Faith(Voi)
a. p$_{1/2}$			*!	
☞ b. b$_1$				*
c. m̥$_2$	*!			
d. m$_2$		*!		*

(b) Voiced consonants /*b, d, g*/

$\{[+\text{voi}]_1; [+\text{nas}]_2\}+/b/$	Dep(Voi)	MReal	Faith(Nas)
a. p$_{1/2}$	*!	*	
b. b$_1$		*!	
c. b$_2$		*!	
☞ d. m$_2$			*

(c) Nasal consonants /*m, n*/

$\{[+\text{voi}]_1; [+\text{nas}]_2\}+/m/$	Dep(Voi)	Dep(Nas)	MReal
a. p$_{1/2}$	*!	*	*
b. b$_1$		*!	*
☞ c. m$_{1/2}$			*

(d) Liquids /*r, l*/

$\{[+\text{voi}]_1; [+\text{nas}]_2\}+/r/$	Ident(Son)	MReal
☞ a. r$_1$		*
b. r̃$_2$	*!	
c. n$_2$	*!	

(e) Voiceless alveolar fricative /*s*/

$\{[+\text{voi}]_1; [+\text{nas}]_2\}+/s/$	*z	*s̃	Dep(Voi)	Dep(Nas)	MReal
☞ a. s$_{1/2}$					*
b. z$_1$	*!				
c. s̃$_2$		*!			
d. n$_1$				*!	
e. n$_2$			*!		

ran into problems when applied to the phonology of lenition, while my system could be extended quite naturally (see Section 5.2.3). Secondly, the issues raised by Wolf can be easily resolved by using MaxFlt in conjunction with MReal, as will be seen in the discussion of lenition.

Gnanadesikan (1997) proposes a powerful and elegant method for dealing with the phonology of eclipsis, within her theory of phonology with ternary scales. Gnanadesikan's ternary scales take the place traditionally occupied by binary/privative features in making phonological distinctions. For example, she replaces the traditional features [voi] and [son] with an Inherent Voicing Scale (Gnanadesikan, 1997, p.1).

(36) Inherent Voicing Scale:

voiceless obstruent,	voiced obstruent,	sonorant
(IV1)	(IV2)	(IV3)

A new constraint, Ident-Adj[IV], requires that the output feature value may move no more than one step along the ternary scale. Thus, Gnanadesikan manages to very neatly account for the chain-shift observed in Irish eclipsis.

Gnanadesikan's theory is very powerful in dealing with eclipsis; however, like Wolf, she faces some difficulty in accounting for lenition, particularly for sonorants and */f/*. It is therefore clear that phonology with ternary scales would not be an appropriate framework for this project, given that the aim is to develop a fully generalised theory of Irish mutation.

5.2.3 Phonology of lenition in OT

We will now turn to the phonology of lenition. This is slightly more complex than eclipsis, due to the presence of a deletion allomorph, ∅. It is defined as follows:

(37) ∅: Deletes a segment, but preserves its secondary articulatory features

This allomorph is introduced purely to deal with the problems posed by lenition of */f/* (see Section 3.3), and is therefore a somewhat awkward add-on to the theory. Nevertheless, it must be included if the theory is to cover all mutations in Irish.

Tables 14a–14f present OT tableaux for the phonology of lenition in Irish. As before, MReal ensures that the lenition morpheme triggers some detectable change in the output. In this case, the change could be either the realisation of [+cont], [-cor] or [+cont]+[-cor] in the output (where it is not present in the input form), or the deletion of a segment. High ranking of *Del ensures that the deletion allomorph (∅) is used only when there is no other option.

The non-alveolar stops */p, b, m, k, g/* are already specified for [-cor], but MReal is satisfied by the inclusion of [+cont] (Table 14a). Similarly, the voiceless alveolar fricative

Table 14: Tableaux for phonology of lenition in Irish

(a) Non-alveolar stops /*p, b, m, k, g*/

$\{[+\text{cont}][-\text{cor}]_1;\ \varnothing_2\}+/p/$	MReal	MaxFlt	*Del	Faith(Cont)
a. p_1	*!	*		
☞ b. f_1				*
c. $\varnothing_2$			*!	

(b) Voiceless alveolar fricative /*s*/

$\{[+\text{cont}][-\text{cor}]_1;\ \varnothing_2\}+/s/$	MReal	*Del	Faith(Cor)
a. s_1	*!		
☞ b. h_1			*
c. $\varnothing_2$		*!	

(c) Voiceless alveolar stop /*t*/

$\{[+\text{cont}][-\text{cor}]_1;\ \varnothing_2\}+/t/$	MReal	MaxFlt	*Del	Faith(Cor)
a. t_1	*!	**		
b. s_1		*!		
☞ c. h_1				*
d. $\varnothing_2$			*!	

(d) Voiced alveolar stop /*d*/

$\{[+\text{cont}][-\text{cor}]_1;\ \varnothing_2\}+/d/$	*ɦ	MReal	Faith(Voi)	*Del	Faith(Dor)
a. d_1		*!			
b. ɦ_1	*!				
c. h_1			*!		
☞ d. ɣ_1					*
e. $\varnothing_2$				*!	

(e) Voiceless bilabial fricative /*f*/

$\{[+\text{cont}][-\text{cor}]_1;\ \varnothing_2\}+/f/$	MReal	*Del
a. f_1	*!	
☞ b. $\varnothing_2$		*

(f) Sonorants /*n, r, l*/

$\{[+\text{cont}][-\text{cor}]_1;\ \varnothing_2\}+/n/$	Ident(Son)	MReal	MaxFlt	*Del
☞ a. n_1		**	*	
b. s_1	*!		*	
c. h_1	*!			
d. $\varnothing_2$	*!			*

/*s*/ is already specified for [+cont], but MReal is satisfied by the inclusion of [-cor] (Table 14b).

In the case of the voiceless alveolar stop /*t*/, we come across the problem raised by Wolf (2008), whereby a mutation morpheme could potentially change multiple features, but need only change one to satisfy MReal. This issue is dealt with by including a further constraint, MaxFlt, which requires that all autosegments floating in the input have output correspondents. Thus, both [+cont] and [-cor] are realised in this case (Table 14c).

The voiced alveolar stop /*d*/ follows a similar process. However, in this case, the result of adding [-cor] and [+cont] to the segment is a voiced glottal fricative /ɦ/, which is prohibited in Irish. Therefore, the segment moves to the nearest available voiced fricative, /ɣ/ (Table 14d).

The voiceless bilabial fricative /*f*/ is already specified for both [-cor] and [+cont], making it impossible for the first allomorph to satisfy MReal. The deletion allomorph ∅ is therefore realised instead (Table 14e).

Finally, the non-lenition of the sonorants /*n, r, l*/ is accounted for through the highly-ranked constraint Ident(Son), just as with eclipsis (Table 14f).

The theory put forward here succeeds in accounting for both lenition and eclipsis data using only universal constraints, and (with the exception of /*f*/) no additional ad hoc rules are required. The next section will explore the triggering mechanism in more detail, and discuss how it might be accounted for in an OT framework.

5.3 Triggering mechanism in OT

5.3.1 Theoretical assumptions

Tables 4 and 5 (Section 2) demonstrate the wide variety of morphosyntactic contexts that trigger ICM in Irish. It is clear at a glance that no single unifying feature can account for the broad range of environments listed in these tables. Furthermore, the triggering of mutation depends on both the syntactic environment and the intrinsic properties of the target word itself (gender, number, tense, etc.).

Most previous theories of mutation have assumed that the mutation-inducing element is associated with the triggering word – consider for example Hamp's morphophonemes, Duffield's lexicalised functional heads, or Pyatt's mutation diacritics (Sections 3.2, 3.5 and 3.6, respectively). However, I would argue that this approach cannot adequately account for the data in Tables 4 and 5.

First, it fails to consider the impact of intrinsic properties of the target word on the triggering of mutation. For example, in environment (A7) (Table 4), lenition is triggered after certain numerals, but only if the target word has singular number. This cannot be easily accounted for if the mutation-inducing element is associated exclusively with the triggering word.

Furthermore, this approach struggles to explain situations in which mutation is triggered in a non-adjacent word. It is difficult to understand why a mutation-inducing element would select a non-adjacent target and pass over the intervening words. Similarly, it is hard to see how a single element could trigger mutation in more than one target (cf. Example (4), reproduced as (38) below).

(38) *trí* ***sh**ioc* *agus* ***sh**neachta*
through ice.L and snow.L
'through ice and snow'

Finally, the association of mutation-inducing elements with the triggering word does not make sense in situations where the trigger is not a word itself. For example, in environment (E1) (Table 5), mutation is induced after a preposition and the definite article *an*. It is unclear whether the eclipsis-inducing element should be attached to the preposition or the definite article (both of which may induce lenition when alone in other contexts), and any attempt to somehow attach it to the combined "prep+*an*" is equally problematic. Furthermore, in some environments there is no overt triggering word at all – consider the lenition of past tense verbs (environment (C1) in Table 4).

For these reasons, I propose that the mutation-inducing affixes defined in the previous section are fundamentally associated with the target word, rather than the trigger.

The next challenge is to understand the mechanism by which the mutation affix is realised on the target word, within an OT framework. It is important to note that the phonological theory developed in Section 5.2 depends crucially on the presence of mutation morphemes in the input; otherwise MReal, MaxFlt and the other faithfulness constraints would not be effective. This gives us two distinct options:

- **Serial method:** Taking what K. Russell (1999) describes as the "assembly line view" of language, a "morphology tableau" is used to determine whether or not the affix is included; the output of this is then entered as the input of a "phonology tableau", identical to those in Tables 14 and 13.
- **Parallel method:** Morphology and phonology are evaluated together in a single tableau; for this to work, the mutation morphemes must be present in the input form of the target word, and constraints are used to decide whether or not the mutation affix is realised in the output.

Bearing in mind that the original motivation for applying OT to the problem of ICM was to take advantage of its power to manage interface phenomena, I have opted for the parallel method. This leads to the slightly bizarre conclusion that potential target words are specified for both lenition and eclipsis in their underlying form. I claim that this result, although initially surprising, captures the full range of data to an extent that no previous theory of ICM has achieved.

5.3.2 Input form and morphological constraints

In order to provide evidence for this claim, I must first demonstrate how the proposed triggering mechanism would work in practice. Consider for example the Irish word *bróg* 'shoe'. This word can undergo both lenition and eclipsis (depending on context), and its input form is therefore specified with both the lenition and eclipsis morphemes (***L*** and ***E***, defined in (33) above), in addition to the usual phonological input form:

(39) Input form for *bróg* 'shoe':
{***L***, ***E***}–/broːg/

Morphological information such as gender, number or tense is also specified in the input (however, due to limits on space, this information will not be indicated explicitly in the OT tableaux below).

To select the correct output form in a given context, a set of morphological constraints must be added to the system. These constraints can be divided into two classes. The first class consists of markedness constraints, which prohibit the realisation of ***L*** and ***E*** in the surface form of a word:

(40) a. ****LE***: Prohibits the simultaneous realisation of ***L*** and ***E*** in the output
b. ****L***: Prohibits the realisation of ***L*** in the output
c. ****E***: Prohibits the realisation of ***E*** in the output

The second class consists of context-dependent constraints. There will be one constraint for each mutation context (see Tables 4 and 5), with the following form:

(41) a. [environment]⇒***L***: In the given environment, realise ***L*** in the output
b. [environment]⇒***E***: In the given environment, realise ***E*** in the output

The environment can include information relating to both the syntactic context and the intrinsic properties of the word itself – in other words, the information provided in Tables 4 and 5. For clarity, I will refer to environments by the label given in these tables; thus the constraint "A1⇒***L***" requires that ***L*** is realised in the output if the word is [NOM SG F] and appears after the definite article *an*.

Note that unlike the phonological constraints discussed in Section 5.2, the morphological constraints proposed here are not universal, but language-specific. This is not entirely unexpected, as the morphemes ***L*** and ***E*** themselves are evidently particular to Modern Irish, and the morphosyntactic triggering environments refer to concepts such as gender and case, which are not necessarily found in all languages. Indeed, Green (2007, pp. 8–11) argues that all language-specific constraints are morphological, while all phonological constraints are universal. His view is consistent with the theory being advanced here.

The proposed ordering of morphological constraints is given in (42) (where "phon. consts." refers to the phonological constraints discussed in Section 5.2):

(42) $*\boldsymbol{LE} \gg$ [context-dependent constraints] $\gg *\boldsymbol{L}$, $*\boldsymbol{E} \gg$ [phon. consts.]

5.3.3 Demonstration of the triggering process

Tables 15a-15c present OT tableaux for the triggering of mutation in Irish, using the example of *bróg* 'shoe'.

Table 15: Tableaux for triggering of mutation in Irish

(a) No mutation triggered in *bróg* 'shoe'

{***L***, ***E***}–/*broːg*/	$*\boldsymbol{LE}$	A1⇒***L***	E1⇒***E***	…	$*\boldsymbol{L}$	$*\boldsymbol{E}$	[phon. consts.]
a. ṽroːg$_{\boldsymbol{LE}}$	∗!						
b. vroːg$_{\boldsymbol{L}}$					∗!		
c. mroːg$_{\boldsymbol{E}}$						∗!	
☞ d. broːg							

(b) Lenition triggered in *an bhróg* 'the shoe'

an + {***L***, ***E***}–/*broːg*/	$*\boldsymbol{LE}$	A1⇒***L***	E1⇒***E***	…	$*\boldsymbol{L}$	$*\boldsymbol{E}$	[phon. consts.]
a. ṽroːg$_{\boldsymbol{LE}}$	∗!						
☞ b. vroːg$_{\boldsymbol{L}}$					∗		
c. mroːg$_{\boldsymbol{E}}$		∗!				∗	
d. broːg		∗!					

(c) Eclipsis triggered in *ar an mbróg* 'on the shoe'

ar an + {***L***, ***E***}–/*broːg*/	$*\boldsymbol{LE}$	A1⇒***L***	E1⇒***E***	…	$*\boldsymbol{L}$	$*\boldsymbol{E}$	[phon. consts.]
a. ṽroːg$_{\boldsymbol{LE}}$	∗!						
b. vroːg$_{\boldsymbol{L}}$			∗!		∗		
☞ c. mroːg$_{\boldsymbol{E}}$						∗	
d. broːg			∗!				

In all cases, the highly-ranked constraint $*\boldsymbol{LE}$ prohibits the simultaneous realisation of lenition and eclipsis. This means that at most one mutation can be realised in any given context.

In Table 15a, *bróg* is considered as a stand-alone word, with no mutation context. The constraints $*\boldsymbol{L}$ and $*\boldsymbol{E}$ prohibit lenition and eclipsis respectively, and so the word appears in its unmutated form.

In Table 15b, *bróg* appears after the definite article *an*. Because it is also a feminine singular word, it satisfies all the morphosyntactic conditions for environment (A1) in Table 4. Therefore, the constraint "A1⇒***L***" is satisfied only if the output form is specified for lenition. The phonological constraints discussed in Section 5.2, in particular MReal, ensure that the correct lenited form of the word is selected.

Similarly, in Table 15c, *bróg* appears after *ar an* 'on the', satisfying the morphosyntactic conditions for environment (E1) in Table 5. Therefore, the constraint "E1⇒***E***" is satisfied only if the output form is specified for eclipsis. Once again, the phonological constraints ensure that the correct eclipsed form of the word is selected.

5.3.4 Advantages of specifying mutation morphemes in the input

It should be clear that this approach removes the modular divisions of grammar entirely from the analysis of ICM. Like K. Russell (1999), I have rejected the assembly line view in favour of a parallelised approach. The advantage of this is that mutations are analysed within the realms of both phonology and morphosyntax, with the possibility of interactions between these modules (see Section 5.4).

In addition, the theory put forward here can account for some of the more puzzling aspects of ICM in Irish. For example, it was mentioned in Section 2.4 that ICM is restricted to the lexical (content) word categories – namely, nouns, adjectives and verbs. Under the current analysis, this makes perfect sense – the only words that can undergo mutation are those which are specified with mutation morphemes in the lexicon. The specification of mutation morphemes in the input form can be seen as representing the "potential" of a given word to undergo mutation. In Irish, only nouns, adjectives and verbs are specified with mutation morphemes, so it is only these classes that can be mutated. Similarly, many loanwords and foreign placenames are resistant to mutation (Chudak, 2010; Stenson, 1993), because these words may not be specified with mutation morphemes.

Furthermore, this analysis explains why the exact same consonant mutations are found in such a wide range of seemingly unrelated contexts. Rather than assuming that the exact same two mutation-triggering morphemes are present (by coincidence) in every single mutation context, my theory proposes that the mutation contexts simply bring to surface a single morpheme that was already present.

Finally, it explains why the mutation morphemes themselves tend not to hold any semantic content – this is because they are simply a property of the target word, and do not possess an intrinsic meaning of their own. However, mutations are still used to make semantic distinctions in certain contexts (Examples (1) and (2), and environment (C1)). In this sense, they act more like phonemes than morphemes; they arguably lie on the boundary between these two categories.

5.4 Irregularities in the Irish data

5.4.1 Precedence of certain environments over others

It was mentioned in Section 2.5 that when a word satisfies the properties for two conflicting triggering contexts, one of the environments takes precedence over the other (Example (5), repeated here as (43)).

(43) a. *ár dhá* ***gc****apall*
our two horse.E
'our two horses'

b. **ár dhá* ***ch****apall*
our two horse.L
'our two horses'

In this example, eclipsis environment (E3) takes precedence over lenition environment (A7). In OT, this is very easily accounted for by assuming the following constraint ranking:

(44) Constraint ranking for conflicting triggering environments:
[(E3)⇒***E***] ≫ [(A7)⇒***L***]

Table 16 demonstrates how this ranking ensures that the correct output form is selected.

Table 16: Tableau for conflicting triggering environments - *ár dhá gcapall*

ár dhá + {***L***, ***E***}–/*kapəl*/	****LE***	E3⇒***E***	A7⇒***L***	****L***	****E***	[phon. consts.]
a. ɣapəl$_{\boldsymbol{LE}}$	*!			*	*	
b. xapəl$_{\boldsymbol{L}}$		*!		*		
☞ c. gapəl$_{\boldsymbol{E}}$			*		*	
d. kapəl		*!	*			

5.4.2 Blocking of mutation for coronals

Recall from Tables 4 and 5 that certain environments do not trigger mutation when alveolar consonants come together at the mutation boundary, an effect that is termed 'coronal fusion' or CF (cf. Ní Chiosáin (1991), Section 3.3.2). Green (2008) incorporates this into his theory of mutation as pure morphology (Section 3.4.1) by introducing a new constraint to the system. Here I will follow Green's approach, adapting it slightly to suit the integrated OT theory described in the previous two sections.

Green claims that the domain of CF is the recursive prosodic word (ω), which comprises right-headed (45-a) and left-headed (45-b) nominal compounds, and prefix + root (45-c) and proclitic + host (45-d) constructions (Green, 2008, p. 201).

(45) a. $_\omega$($_\omega$(ar**d**) $_\omega$(**s**agart))
high priest
'high priest'

b. $_\omega$($_\omega$(to**nn**) $_\omega$(**t**uile))
wave flood.GEN
'tidal wave'

c. $_\omega$($_\omega$(a**n**) $_\omega$(**d**eas))
very nice
'very nice'

d. $_\omega$($_\omega$(a**n**) $_\omega$(**t**airbh))
the bull.GEN
'of the bull'

Note that mutation is blocked when two coronal consonants come together, despite the fact that these are all ordinarily lenition environments. Green introduces the following syntagmatic constraint to account for this phenomenon (Green, 2008, p. 207):

(46) Coronal Homorganicity:
CorHom: Requires that within ω, a coronal consonant shares a place of articulation with a following consonant

CorHom outranks the context-dependent constraints, blocking mutation in the situations described above. It is in turn outranked by Dep(Cor), in order to prevent non-coronal consonants from becoming [+cor] in the output:

(47) Dep(Cor) ≫ CorHom ≫ [context-dependent constraints]

These additional constraints correctly predict which contexts lead to blocking of mutation (Table 17a) and which do not (Table 17b).

Table 17: Tableaux to demonstrate coronal blocking

(a) Mutation blocked in *seanduine* 'old person'

ʃan + {$\boldsymbol{L}$, $\boldsymbol{E}$}–/*dinʲə*/	Dep(Cor)	CorHom	D1$\Rightarrow\boldsymbol{L}$	$*\boldsymbol{L}$
a. ʃan ɣinʲə		*!		*
☞ b. ʃan dinʲə			*	

(b) Mutation allowed in *seanghoimh* 'old sore'

ʃan + {$\boldsymbol{L}$, $\boldsymbol{E}$}–/*givʲ*/	Dep(Cor)	CorHom	D1$\Rightarrow\boldsymbol{L}$	$*\boldsymbol{L}$
☞ a. ʃan ɣivʲ$_{\boldsymbol{L}}$		*		*
b. ʃan givʲ		*	*!	
c. ʃan divʲ	*!		*	

5.4.3 Anti-lenition for /*s*/

Section 4 introduced the phenomenon of anti-lenition, which applies to environments (A1) and (A2), a subset of the coronal blocking environments discussed in the previous section. In anti-lenition environments, /*s*/ is mutated to /*t*/ instead of the usual /*h*/.

In OT, this can be explained via the introduction of an anti-lenition morpheme, defined in (48):

(48) Anti-lenition morpheme:
aL = { [-cont] }

Words with initial consonant /*s*/ are specified with ***aL*** in their input forms, in addition to specifications for ***L*** and ***E***. Two new constraints, "A1⇒***aL***" and "A2⇒***aL***", trigger the realisation of ***aL*** in the relevant environments. This creates a conflict between triggering environments (cf. Section 5.4.1), which is resolved by the presence of CorHom (Table 18).

Table 18: Tableau for anti-lenition in *an tslat* 'the rod'

an + {***L***, ***E***, ***aL***}–/*slat*/	CorHom	A1⇒***L***	A1⇒***aL***	****L***	****aL***
a. slat		∗	∗!		
b. hlat$_{\boldsymbol{L}}$	∗!		∗	∗	
☞ c. tlat$_{\boldsymbol{aL}}$		∗			∗

Words with initial consonants other than /*s*/ are not specified for ***aL***, and are therefore unaffected by this process.

5.4.4 Dialectal variation

In OT, variation can be expressed through a simple reordering of constraints. Many of the dialectal differences discussed in Section 2.6 can be explained in this way. For example, the mutation /*s*/ → /*z*/ under eclipsis (Connacht) can be attributed to a lower ranking of **z* in Connacht Irish. Similarly, the lack of coronal blocking in environment E1 (Munster) suggests that "E1⇒***E***" outranks CorHom in Munster Irish.

In some cases, there is variation within a dialect – consider the case of /*f*/ in Connacht Irish, which is lenited in some cases but not in others (Section 2.6.2). This suggests there is no outright "winner" in the conflict between MReal and *Del, or in other words, that neither crucially outranks the other. Compare Table 19 with Table 14e (Section 5.2.3).

In Table 19, both candidates are selected as optimal, because the constraint hierarchy does not prioritise one over the other. Therefore, either candidate may be chosen in the output form.

Table 19: Tableau to demonstrate variable lenition of /*f*/ (Connacht Irish)

$\{[+\mathrm{cont}][-\mathrm{cor}]_1;\ \varnothing_2\}+/f/$	MReal	*Del
☞ a. f_1	*	
☞ b. $\varnothing_2$		*

Some dialectal differences require the introduction of a new context-dependent constraint to the system, either replacing or outranking the corresponding constraints in the standard variety. For example, the lenition of words in environment (E1) in Donegal Irish (instead of the standard eclipsis) can be explained via the following constraint replacement:

(49) $\mathrm{E1}\Rightarrow\boldsymbol{E} \longrightarrow \mathrm{E1}\Rightarrow\boldsymbol{L}$ (Donegal Irish)

The only dialectal variants that remain unaccounted for under this theory are lenition as loss of tension in /ʟ, ɴ/ (Donegal/Connacht) and lenition of /*r*/ through palatalisation (Munster). However, it was observed in Section 2.6 that these features are extremely rare, and usually found only among older speakers. This suggests they may be remnants of historical varieties of Irish, and are therefore largely irrelevant to a synchronic analysis of the language.

5.5 The OT solution: Summary

This chapter proposed a novel approach to ICM, within the framework of Optimality Theory. Mutation is triggered by the presence of "mutation morphemes", which consist of sets of floating phonological features (with the exception of the deletion allomorph ∅, included to account for lenition of /*f*/). These morphemes are assumed to be present in the input form of the target word, expressing the "potential" for that word to undergo mutation. Candidate output forms are evaluated against each other in a single OT tableau, which includes both morphological and phonological information. The universal phonological constraints are supplemented by a set of language-specific morphological constraints that determine the environments in which the mutation morphemes are realised.

The OT solution directly addresses many of the theoretical problems raised in Section 2.5. In particular, it provides a fully integrated treatment of ICM, giving equal weight to phonology, morphology and syntax. In doing so, it manages to explain some of the major irregularities in the Irish data, without resorting to convoluted or ad hoc measures (Section 5.4). Furthermore, the decision to specify mutation morphemes in the input form of words brings an improved understanding of the role played by mutations in Irish, accounting for both the restriction of mutation to content words and the wide range of environments in which mutation is found (Section 5.3.4).

6 Conclusions and Further Study

This dissertation explored the phenomenon of initial consonant mutation in Modern Irish, which occurs at the boundary between phonology, morphology and syntax. Noting that most previous approaches to the problem favoured either a phonological or a morphological viewpoint, this project sought to advance an integrated theory of ICM that could account for the full range of complexities in the data. Optimality Theory was demonstrated to be an ideal framework for such a theory, as it allows different modules of grammar to be handled simultaneously.

The proposed solution differs in several important ways from previous theories of ICM. First, it replaces the traditional "assembly line" view of grammar with a fully parallelised system. This means that phonological and morphological constraints can interact without resorting to ad hoc rules. In addition, the mutation-inducing element is assumed to be fundamentally associated with the target word, rather than with the trigger. As well as greatly simplifying the analysis, this insight leads to an increased understanding of the theoretical system underpinning the Irish mutations. In particular, it emphasises the fact that the potential for mutation is already present in the underlying form of the target word, and that the triggering environments simply bring that latent possibility of mutation to the surface. This could explain why the exact same initial consonant mutations are found in such a diverse range of contexts.

The theory proposed here is just a foundation, and it leaves many questions open for further research. For example, while the phonological constraints fit into well-defined universal constraint families, the context-dependent morphological constraints do not. It would be interesting to study the nature of these constraints, and to explore whether similar schemata for constraints are found elsewhere. It is also crucial to understand how this theory would assimilate into a general OT theory of Irish grammar – for example, is the proposed constraint hierarchy consistent with constraint rankings observed in the rest of the language? Finally, one could explore whether the theory could be extended to mutations in other Celtic languages, such as Scottish Gaelic or Welsh. Such research would hopefully yield generalisations and insights into the ICM phenomenon as a whole.

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A List of Abbreviations

1/2/3	First/second/third person
aL	Anti-lenition – an alternative mutation for words beginning with /s/
AUT	Autonomous verb form
C/CP	Complementiser (node) / Complementiser Phrase
CON	Conditional
COP	Copula
D/DP	Determiner (node) / Determiner Phrase
DAT	Dative
DEF	Definite
E	Eclipsis
F	Feminine
FP	Functional Phrase
GEN	Genitive
HAB	Habitual
IND	Indicative
INDEF	Indefinite
L	Lenition
M	Masculine
N/NP	Nominal (node) / Noun Phrase
NEG	Negative particle
NOM	Nominative
P/PP	Prepositional (node) / Prepositional Phrase
PREP	Preposition
PRES	Present
PRT	Particle
PAST	Past
PL	Plural
REG	Regular verb
SG	Singular
T/TP	Tense (node) / Tense Phrase
Ta	Mutation target
Tr	Mutation trigger
VOC	Vocative
VN	Verbal noun
ω	Prosodic word (pword)

B List of OT Constraints

*X	Prohibits realisation of segment/feature X
*Complex	Syllables have at most one consonant at an edge
*Del	Prohibits deletion of input segments in the output
*___E___	Prohibits realisation of ___E___ in the output
*___L___	Prohibits realisation of ___L___ in the output
*___LE___	Prohibits simultaneous realisation of ___L___ and ___E___ in the output
Align	The edges of two morphological/phonological/prosodic categories must match
CorHom	Within ω, a coronal consonant shares a place of articulation with a following consonant
Dep(X)	Segment/feature X in the output has an identical correspondent in the input
Faith(X)	Feature value of X in an output is identical to that of the corresponding input segment
Ident(X)	Segment containing feature X in the input remains entirely unchanged in the output
Max(X)	Segment/feature X in the input has an identical correspondent in the output
MaxFlt	All autosegments floating in the input have output correspondents
MReal	Every morpheme must be realised in an overt and detectable manner
NoCoda	Syllables end with a vowel
NoVacDoc	Floating features cannot dock onto segments that already bore the same feature value in the input
Onset	Syllables begin with a consonant
Peak	Syllables have one vowel
S-Ident(X)	Adjacent segments are identical in feature X
*V-Coda	Obstruents must not be voiced in coda position
[X]⇒___E___	In environment X, realise ___E___ in the output
[X]⇒___L___	In environment X, realise ___L___ in the output

Note: The constraints are listed here as defined in this dissertation; they may be defined differently elsewhere.