The Blurring Effect of Sonorants and Vocalic Alternations in Irish

A thesis submitted in satisfaction of the requirements for the degree
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By
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Abstract

This thesis explores the hypothesis that a postvocalic sonorant (including a glide or a vowel) exerts a *blurring effect* on the preceding vowel, that is, the perception of the auditory image of the vowel, and the recognition of the vowel quality, is degraded when the vowel is followed by a sonorant, compared to other sorts of post vocalic material.

Two factors are responsible for the *blurring effect*:

a) The tendency of sonorants to involve anticipatory articulatory gestures that are not directly related to the place of articulation, and which result in a different, non-canonical shape of the vocal tract during the vowel, and hence non-canonical resonations and non-canonical, ‘coloured’ acoustics of the vowel.

b) A higher-level auditory factor, namely backward masking, which is the tendency of a loud sound to mask a preceding, categorically-similar, sound. It is claimed that sonorants are both loud and categorically similar to vowels, and hence serve as perfect maskers.

The effectiveness of both factors across vowel qualities and quantities and syllabification patterns is also discussed.

It is claimed that the degradation in the perceptibility of vowel quality as a result of the *blurring effect* might invoke repair mechanisms of the grammar that restore the perceptibility of vowel quality and help vowels overcome the *blurring effect*.

Various phonological alternations in Irish are discussed as manifestations of such repair mechanisms, and are explained in an informal, constraint-oriented, account which incorporates the *blurring effect* into the grammar.

Finally, the details of the *blurring effect* hypothesis and its alleged manifestations in Irish are subject to empirical validation in a series of pilot experiments on vowel perception, and most of them seem to be unequivocally validated by these pilot experiments.
1 Introduction

1.1 Overview of the Thesis
This thesis discusses the interrelation between sonorant consonants and preceding vowels, and suggests the hypothesis that the presence of a sonorant immediately after a vowel degrades the perception of the quality of the vowel. This degradation, which is termed ‘the blurring effect of sonorants’ is typically a low-level, acoustic and auditory property of speech, but in certain circumstances it becomes dominant enough to affect the high-level phonological system. Irish, it is claimed, is a language whose phonological system provides such environments, and certain phonological alternations that take place in these environments in Irish will be presented and accounted for as manifestations of the reaction of the phonological system against the emerging degradation in the perception of vowel quality.

The structure of the thesis is as follows: The rest of this chapter provides brief introductions to the various issues pursued in the various chapters. Chapter 2 explores in detail the blurring effect hypothesis. Chapter 3 presents the Irish data and highlights those aspects that are relevant to the blurring effect hypothesis. Chapter 4 proposes accounts of the various phonological alternations in Irish, and these accounts are based on repair mechanisms that help the perceptual system to overcome the blurring effect. Finally, chapter 5 describes an experimental study that has been carried out in order to provide empirical support for the blurring effect hypothesis as well as for the validity of the perceptual enhancement of the repair mechanisms in Irish.

1.2 The Blurring Effect of Sonorants
The theoretical hypothesis explored in this thesis is that sonorant consonants (including glides and also vowels) exert an auditory blurring effect on an immediately preceding
vowel, that is, the quality of this vowel is perceptually blurred as a result of the presence of a following sonorant, compared to a more canonical perception of the quality of pre-obstruent or utterance-final vowel. This hypothesis is developed in chapter 2.

The blurring effect, it will be claimed, is a cumulative result of regressive co-articulatory colouring and auditory backward masking of the vowel quality by the following sonorant.

Regressive co-articulatory colouring, that is, a substantial deviation from the prototypical acoustic quality of the vowel, results from certain anticipatory articulatory maneuvers that are particular to sonorants in the sense that they are additive to the ordinary transient articulatory gestures that characterise any transition from a vowel (or any sound) to a following consonant (or any sound). Such gestures are velum lowering for nasal articulation, resulting in vowel nasalisation; retroflexion and lip rounding for coronal approximants, resulting in vowel rhoticisation; retraction and lowering of the tongue body for both laterals and coronal trills, resulting in an altered oral cavity; and finally a slow and gradual transition of the tongue body for dorsal trills, approximants, glides and vowels, resulting in an unsteady and transient shape of the oral cavity.

Auditory backward masking is the term used to describe the degradation in detection, perception and categorisation of a sound (the ‘target’) as a result of exposure to a following sound (the ‘masker’). It is a property of any pair of consecutive sounds, but the level of masking, and the corresponding level of perceptual degradation, depends on the properties of the sounds involved: the level of masking increases the shorter the interval between the target and the masker; the smaller the target-to-masker duration ratio; the smaller the target-to-masker loudness ratio; the greater categorical auditory similarity between the target and the masker; and the more probable the co-
occurrence of the auditory neural images of the target and the masker within the auditory short-term memory buffer.

Post-vocalic sonorants, it will be claimed, inherently fulfil most of these conditions, as they are both immediately following the vowel, they are louder than other sounds, and they belong to the same auditory category as vowels, both being formant-dependent sounds. As such they have a categorically higher backward masking potential over vowels, compared to obstruents. If they also happen to be relatively long, and if they are tauto-syllabic with the preceding vowel and thus more likely to co-occur with the vowel in the auditory short-term memory (which, it will be claimed, is rhyme-biased), they fulfil all these conditions, and their masking potential is even greater.

1.3 Vocalic Alternations in Irish

Irish, it is claimed in chapter 3, is a language whose phonological system provides environments where the masking potential of sonorants over certain preceding vowels is so great that, together with their regressive co-articulatory colouring, they exert a substantial *blurring effect* over preceding vowels, to the extent that the grammar reacts with certain phonological alternations.

Robust phonetic secondary articulation of consonants allows only negligible co-articulatory effects of vowels over adjacent consonants, and therefore the auditory quality of a consonant cannot facilitate the auditory perception of the quality of an adjacent vowel, so that vowels are ‘left on their own’.

Among the vowels, quality-distinct short vowels are most vulnerable to *blurring*, and it will be claimed that fully voiced tauto-syllabic (coda) sonorants exert a strong *blurring effect* on such vowels. Furthermore, Irish has a contrast between lax sonorants, which are inherently shorter, and tense sonorants, which are inherently longer, and it will be claimed that the tense sonorants exert an even stronger *blurring effect*. 
In order to illustrate the uniqueness of such an environment in Irish, certain phonological alternations that take place when a quality-distinct short vowel is followed by a fully voiced tauto-syllabic sonorant will be presented in that chapter. These alternations include:

- **Vowel epenthesis after a postvocalic sonorant in certain environments, in most dialects.** E.g.: *dearg* ‘red’ [ˈd̪əɾ̥aɾ̥əg̊].

- **Lengthening of a short vowel before a tauto-syllabic tense sonorant or before certain sonorant-initial consonantal clusters, in the Southern and Western dialects.** E.g.: *am* ‘time nom.’ [ˈaːm̩] as opposed to *ama* ‘time gen.’ [aːm̩ə].

  *inseacht* ‘telling’ [iːnəɾ̥aɾ̥ək̩] as opposed to *inis* ‘Tell!’ [iːnəɾ̥əf̩].

- **Devoicing of a lax sonorant in coda in a monosyllabic word after a short vowel, in the Northern dialect.** E.g.: *fuil* ‘blood’ [f̪u̟ɪɾ̥], *bun* ‘base’ [b̪o̟n̩],

  *fear* ‘man’ [fəɾ̥əɾ̥].

### 1.4 Theoretical Account

Chapter 4 suggests a theoretical account of the phonological alternations presented in chapter 3, and of their historical evolvement. These alternations, it is claimed, involve, or historically involved, repair mechanisms that help the auditory system overcome the **blurring effect** by facilitating the perception of vowel quality.

Both vowel lengthening (i.e. longer ‘target’, and relatively smaller co-articulatorily coloured vowel portion), sonorant devoicing (i.e. quieter ‘masker’) and splitting across syllabic domains by epenthesis (i.e. less likelihood of both co-articulatory colouring and co-occurrence of the ‘target’ and the ‘masker’ within the auditory short term memory buffer) all change the balance between a vowel and a following sonorant and help the vowel to regain its canonical perceptibility in otherwise
crucially blurring circumstances.

Informal algorithms of these mechanisms are sketched and applied over illustrative underlying forms to produce surface forms which are either present in the contemporary dialects of Irish or reconstructed for earlier stages of the language. In the latter case it is also explained how and why these reconstructed forms developed into the different surface forms in the contemporary dialects of Irish.

Finally, previous theoretical accounts of the same phenomena are discussed, and the fundamental differences between these accounts and the current account are highlighted.

1.5 Experimental Validation

Both the blurring effect hypothesis explored in chapter 2 and its alleged phonological manifestations in Irish explored in chapters 3 and 4, involve claims about general and particular auditory perceptual states. These claims remain abstract and tentative unless they are validated empirically by experiments on perception. Chapter 5 describes a pilot experimental study that tested the general hypothesis as well as some of its particular details that seem to have manifestations in Irish.

This experimental study involved the task of phonetic transcription of auditorily presented stimuli, which were real-speech manipulated non-sense words. The subjects were students of linguistics, and most of them were native speakers of Hiberno-English. Each such experiment examined the collective accuracy of vowel transcription, as a reflection of the perception of vowel quality, over a large number of subjects. Across stimuli, only the relevant variables, that is, the postvocalic sound(s), were varied, and the properties of the vowels and preceding environment were kept identical, so that any systematic differences in the collective accuracy of the perception of vowel quality would reflect only the differences among the various
postvocalic sounds.

The following hypotheses were tested, and statistically verified, in the experimental study:

- Vowel quality is indeed significantly degraded by the presence of a postvocalic sonorant compared to a postvocalic obstruent or nothing (i.e. the fundamental hypothesis of the *blurring effect* was confirmed).

- Longer postvocalic sonorants degrade the perception of vowel quality more than shorter postvocalic sonorants (i.e. the *blurring effect* depends on the duration properties of the sonorant).

- The quality of a longer vowel is perceived more accurately than the quality of a shorter vowel in a *blurring* environment (i.e. vowel lengthening reduces *blurring* and enhances the perception of vowel quality).

- The quality of a vowel is perceived more accurately before a devoiced sonorant than before a fully voiced sonorant (i.e. the *blurring effect* depends on the relative loudness and probably also on the formant-dependence of sonorants; sonorant devoicing reduces *blurring* and enhances the perception of vowel quality).

- The quality of a vowel is perceived more accurately before an intervocalic sonorant than before a syllable-final sonorant (i.e. the *blurring effect* depends on the tauto-syllabicity of the vowel and the sonorant, and post-sonorant vowel epenthesis reduces *blurring* and enhances the perception of vowel quality).
2 The **Blurring Effect of Sonorants**

This chapter explores in detail the basic hypothesis behind this thesis, namely that sonorant consonants have an auditory *blurring effect* over a preceding vowel, that is, that the perception of vowel quality is relatively poorer when a vowel is followed by a sonorant consonant. It is claimed, on the basis of the characteristics of auditory processing mechanisms, that such an effect is indeed plausible, and that it might be linguistically relevant.

The chapter starts with a brief introduction to some basic aspects of acoustic and auditory phonetics and proceeds with the acoustic properties of vowels and sonorants and their auditory reflections. It then covers two relevant dynamic elements of audition: quality colouring effects by regressive co-articulation and backward auditory masking. These two elements are combined to form the rationale behind the *blurring effect* hypothesis, which, once set forth, should further be justified as linguistically (phonologically) relevant, given its low-level phonetic nature.

2.1 Basics of Audition

Acoustic signals are pressure fluctuations of air (or other medium) molecules as a function of time. Speech signals are acoustic signals that reflect speech events. Thus, silence followed by an abrupt burst (as in the case of a voiceless stop) is reflected by no fluctuation for a period of time followed by an abrupt large-scale fluctuation; frication turbulences (as in fricatives) are reflected by an uncountable amount of a-periodic and rather messy small-scale fluctuations (as if yielding small periodic fluctuations in a broad bandwidth of frequencies); and vocal chord vibration (as in voiced sounds) is reflected by a larger, periodic fluctuation that roughly resembles a sine wave. Co-occurring fluctuations, which are amplified (and/or damped) in certain
ways by the vocal tract, combine to form the speech signal. According to Fletcher (1953:106-109), as the acoustic signal reaches the ear and hits the eardrum, the eardrum vibrates according to the fluctuations inflicted by the signal, and its vibrations are conducted, via a chain of three bones (the ossicles), to the fluid canal inside the cochlea. Inside the cochlea, along the fluid canal, is the nerve-crowded basilar membrane. The auditory nerves, which project from the basilar membrane into the canal of the cochlea in the form of hair cells, fire neural pulses upon excitation by fluid vibrations in the cochlea canal.

The rate of neural pulses fired by an auditory nerve upon a fluctuation at a given frequency depends on (a) the frequency of the fluctuation and (b) the intensity of the fluctuation (Fletcher 1953:110-118). Depending on its position along the basilar membrane, each auditory nerve responds only to fluctuations within a certain range of frequencies, which might span an octave or more. Within that range, however, fluctuations at peripheral frequencies excite neural pulses in negligible rates compared to fluctuations with similar intensities but more central frequencies. For any given frequency within the range, between the minimal intensity needed for neural sensation (firing of an auditory pulse) and the intensity at which the firing rate is maximal, the rate of neural pulses correlates with the intensity – the greater the intensity, the higher the rate.

The firing of neural pulses creates the low-level neural image of the acoustic signal. This neural representation, although much smoothened due to the wide range of frequencies for every auditory nerve, is still rather faithful to the original acoustic signal. In ideal speech conditions, i.e. no background noise, no reverberation, near enough speech source and no hearing impairment, this neural image carries most of the information embedded in the speech signal.
The fast Fourier transformation (FFT), as implemented in spectrographs, is widely accepted as a method of signal analysis, which is similar to the process of the basilar membrane, and its (less frequently used) implementation in cochleagrophs is regarded as an even more accurate representation of the low level neural image.

Auditory processing, which starts with neural firing and ends in cognitive recognition, is obviously not easily subjected to direct observation, and its modularisation is more abstract. Following Massaro(1972), Crawley et al. (1994), auditory processing presumably involves (a) storage in a short-term memory store (the pre-perceptual auditory store in Massaro 1972), and (b) extraction or readout of separate units from the short-term memory store and their categorisation according to matching information from the long-term memory, and (c) further storage in some other memory unit (the Synthesised Auditory Memory in Crawley et al. 1994) for further, non-auditory, cognitive processing.

2.2 The Acoustic and Auditory Properties of Vowels and Sonorants

Following Johnson (1997:64) vocal chord vibration, in a similar manner to string vibration, is characterised by the presence of harmonics, that is, periodic fluctuation patterns whose periods are fractions (half, third, quarter etc.) of the vibration period, or cycle, and whose frequencies are therefore integer multiples of the vibration frequency or the fundamental frequency.

During the articulation of voiced sounds with a vocal tract sufficiently open so as to involve no closure or frication, namely oral vowels, glides, liquids and all nasal sounds, the vocal tract simply serves as a resonance box that amplifies certain harmonics and dampens others, in a manner similar to the resonance box of a string instrument. The precise resonations of the vocal tract, and hence the precise harmonics that are amplified or damped, are a function of the sizes of the various cavities in the vocal
tract. Hence different shapes of the vocal tract, which result from different articulatory gestures, yield different harmonic amplification patterns. Thus, different amplification patterns, which are typically referred to according to the range of frequencies of the amplified harmonics, or formants, are the unique acoustic characteristics of the different sounds with relatively open vocal tract (Tarnóczy 1948).

While the presence of formants (or at least one formant) is a property also of most fricatives (amplification of turbulences in certain frequencies according to the size of the front cavity beyond the source of frication), the major acoustic characteristic of these sounds is ‘nearly white noise’, that is, small fluctuations in a broad bandwidth of frequencies. The acoustic expression of vowels, glides, liquids and nasals, on the other hand, is entirely dependent on the combination of various formants, because their only source of noise is vocal chord vibration and its harmonics.

In addition to the formant-dependent acoustic characteristic of vowels, glides, liquids and nasals, they are all characterised by their overall larger spectral amplitude (which reflects larger air pressure fluctuations) compared to other speech sounds (see Fletcher 1953:84-86). This is a direct result of the relatively open vocal tract, which enables a larger volume of airflow.

Given the sketch of the auditory processes above, the low-level auditory neural image of vowels, glides, liquids and nasals is, therefore, that of very intensive pulses from certain confined parts of the basilar membrane, and relatively limited amount of pulses from other ranges. It is precisely this property of these sounds that binds them together under the phonological category of ‘sonorants’ (Boersma 1998:18). Their overall larger amplitude is represented in phonological theory by their higher level in sonority scales (e.g. Spencer 1996:89, Ladefoged 1975:221-222).

Speech sounds are a subset of sounds in general, and there is no reason to assume
that, at the lower levels of neural representation, they differ from non-speech sounds of similar acoustic properties. Many experimental studies on general audition, free from a purely linguistic orientation, use sounds that are different from and simpler than speech sounds, namely pure or complex tones, white noise, ticks and silence. Though simpler, these non-speech sounds directly correspond to the major auditory categories of speech sounds: Pure and complex tones correspond to sonorants (including vowels), white noise corresponds to fricatives, and silence and ticks correspond to the various auditory stages of a stop. Studies on the audition of such sounds are therefore directly relevant to the audition of corresponding speech sounds.

2.3 Some Dynamic Aspects of the Acoustic Signal

2.3.1 Co-articulatory Vowel-Colouring by a Following Sonorant

2.3.1.1 Regressive Co-articulation

Speech is extremely dynamic. Not only does it involve transitions from one sound to another, the speech organs are constantly moving. Steady states, or articulatory targets, are present only for short periods of time (if at all), and the transition from the steady state of one sound to that of another is gradual, involving intermediate stages of articulatory ‘undershooting’ of both sounds.

A very common physiological phenomenon during speech dynamics is that of anticipatory articulatory gestures. During the steady state of one sound, speech organs start moving towards the articulatory targets of the following sound. The phonetic product of this phenomenon is regressive co-articulation, and the phonological product is regressive assimilation.

Pre-sonorant vowels experience several kinds of co-articulatory effects which alter the shape of the vocal tract to a greater extent than those characterising transitions from a vowel to a following obstruent, as the following paragraphs will demonstrate.
2.3.1.2 Vowel Colouring by a Following Nasal
Before a nasal consonant, vowels are typically nasalised to a greater or lesser degree; that is, the anticipatory gesture of velum lowering takes place during the vowel. As a result, the nasal cavity couples with the oral cavity, and the whole vocal tract is altered, with subsequent alterations of its resonations. The peculiarities of nasalised vowels have been a topic of extensive research, and it is well known that their auditory qualities tend to differ significantly from those of their oral counterparts, and that their ‘auditory space’, that is, the possible range of formant frequencies, is more limited than that of oral vowels (see e.g. Wright 1986, Johnson 1997:157-160).

2.3.1.3 Vowel Colouring By a Following Rhotic
‘Rhotics’, or r-sounds, are achieved by many different articulatory strategies. The major ones are coronal (dental/alveolar/retroflex) trill (e.g. Spanish, Italian, Russian), coronal flap (e.g. Spanish), coronal approximant (e.g. English), dorsal (post-velar/uvular) trill (e.g. Portuguese, French), dorsal voiced fricative (French, Iraqi Judeo-Arabic) and dorsal approximant (e.g. Hebrew, German).

As diverse as rhotics may be, they all typically exert some colouring on the quality of a preceding vowel (Lindau 1985).

In the case of dorsal rhotics, whose primary articulator is the tongue body, the reason for this is straightforward: the tongue body position, which is the major factor of vowel quality, changes in order to reach the position of the following target. The target position for all dorsal rhotics involves a critical level of aperture, and therefore its formation must involve a gradual and slow transition, rather than an abrupt ballistic movement as in stops (Boersma 1998:156, Kirchner 1998:51-53). The transition from a vowel to a following dorsal rhotic is essentially similar to the transition within a diphthong, and very different from the transition from a vowel to a
dorsal stop. However, there is a major phonological difference between a diphthong and the transition from a vowel to a dorsal rhotic: A diphthong is commonly an independent phoneme, with the transient vowel quality as an inherent property (see for example Lehiste 1964:5-6). A sequence of a vowel and a dorsal rhotic is typically perceived as two separate phonemes, and the transient quality is an allophonic, atypical variant of the vowel.

The case of coronal rhotics is more complicated, but nevertheless similar in the sense of vowel colouring. As in the case of dorsal rhotics, post-vocalic coronal rhotics involve a gradual, rather than abrupt, movement of the primary articulator, in this case the tongue tip, resulting in some gradual alteration to the shape of the vocal tract. The major colouring effect of coronal rhotics, however, results from other, accompanying gestures: Coronal approximants typically involve gradual tongue retroflexion, labialisation and pharyngealisation (Ladefoged 1975:78), all causing major alterations to the shape of the vocal tract, resulting in the significant alteration of the acoustic quality of a preceding vowel (Lehiste 1964:78-88). In the case of a coronal trill, Recasens (1991, 1999) shows that vibration of the tongue tip is facilitated by lowering of the front parts of the tongue body and retraction of the back parts. This lower and backer tongue body position results yet again in a distortion of the quality of a preceding vowel as in e.g. Spanish (Lewis 1999 and references therein), with the extreme case being the pharyngealised /r/ in Arabic, which, in contrast with the rest of the pharyngealised consonants in this language, has no plain counterpart.

2.3.1.4 Vowel Colouring by a Following Lateral

The transition from a vowel to a plain lateral does not differ much from the transition from a vowel to a coronal obstruent. However, the critically narrow stricture and lateral apertures of laterals are clearly facilitated (Ni Chasaide et al. 1991:23) by the
lowering and retraction of the tongue body, to give the well-known ‘dark’ or velopharyngealised /l/, which is almost as common as plain /l/ in languages that lack systematic secondary articulation (e.g. American English, Dutch, Portuguese, Catalan, see IPA1999). Such an /l/ target involves anticipatory articulatory gestures that again result in altered oral cavities, altered resonations and the atypical auditory quality of a preceding vowel, see e.g. Lehiste (1964:26-28).

2.3.1.5 Vowel Colouring - Summary
Post-vocalic sonorants typically involve anticipatory articulatory gestures that alter the shape of the vocal tract during the vowel, resulting in an altered, non-canonical vowel quality. This is definitely apparent in the study of Guenter et. al (1999). In this experimental study, subjects’ same/different judgements of vowel qualities across word pairs pattern categorically in the case of most post-vocalic consonants (91% ‘same’ replies for same vowels, 96% ‘different’ replies for different vowels). In pairs containing a word with a postvocalic sonorant ([ɛ],[l],[ŋ] and [m]), results were rather different and less categorical: about 80% ‘same’ replies for same-vowel pairs containing [m], about 50% ‘same’ replies for same-vowel pairs containing [ŋ] and [l], and about 20% ‘same’ replies for similar-vowel pairs containing [ɛ]¹.

2.3.2 Backward Auditory Masking – Sonorants Mask Preceding Vowels

2.3.2.1 Introduction to Masking
Masking is the term used to describe the relationship between two (or more) signals, when one signal, the target, is the one that carries the relevant information to the sensory system, and the other signal, the masker, serves as an interfering

¹ Vowel rhoticisation is effective in English to a degree that pre-r vowels don’t really fall into the usual vowel categories, which is precisely the point under discussion in Guenter et al.’s paper.
environment that might impede the perception of the target (Massaro 1972:125).

Masking can be visual, auditory or otherwise sensory. Our concern here is with auditory masking in general, and with speech-internal masking in particular. The hypothesis put forth in this section is that a **post-vocalic sonorant inflicts backward auditory masking on a preceding vowel**, and thus impedes vowel perception.

Masking can be simultaneous (target and masker signals co-occur) or non-simultaneous. Non-simultaneous masking is either **forward masking** if the masker precedes the target, or **backward masking** if the masker follows the target.

The notion of simultaneous masking is somewhat straightforward (e.g. Fletcher 1953:153-175) as the presence of the masker alters the perceived signal and might therefore impede recognition of the target and even override it completely. However, the linguistic relevance of simultaneous masking seems rather negligible, as speech from a single source seldom contains co-occurring unrelated signals. (An exception might be the effect of very high fundamental frequency on the perception of formants in the speech of young children.)

Non-simultaneous masking, on the other hand, might be linguistically relevant, because speech inherently contains consecutive signals. However, the notion of non-simultaneous masking per-se demands some explanation, as the masker and target do not fuse within the signal.

### 2.3.2.2 Non-simultaneous and Backward Auditory Masking

#### 2.3.2.2.1 Scenarios of Non-Simultaneous Masking

In order for non-simultaneous masking to occur, the masker has to interfere with the target at some stage between the lowest level of sensory reception, and the highest level, that of cognitive recognition. Recall from the introduction to audition, that models of audition posit a few stages between these two levels, involving data
transmission, storage in short-term memory, readout of auditory units, auditory
categorisation, and further storage for non-auditory processing.

During these stages, various non-optimally performed procedures might give rise to
non-simultaneous masking of one sound by another.

At the level of data transmission, differences in the temporal responses of auditory
nerves might result in a blended or fused signal within short-term memory. Forward
and backward masking effects should be rather similar in such cases (it is adjacent
sounds that fuse with one another), and the resulting auditory representation is
essentially similar to that of a simultaneously masked signal. Such low-level mal-
performances of temporal resolution of consecutive acoustic events are probably
more characteristic of hearing impaired and/or elderly humans, and are not a property
of human audition in general (Bamford & Sauders 1985:102-104). The resulting
masking effects hardly bear any linguistic relevance as a result.

The process of data storage in short term memory might itself exert some masking,
which is regressive (backward) in nature: Massaro (1973) presents a strong version of
this notion, according to which the storage of a following sound in the short-term
memory overwrites the auditory image of the target, thus terminating the perceptual
processing of the target. This view seems somewhat radical, and stems from the very
categorical findings within the simplified recognition-masking paradigm developed in
Massaro (1970). However, even a more moderate (hypothetical) version of this claim,

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2 Based on experiments on auditory detection, Massaro(1972:126) argues that louder sounds result in
faster neural response than quieter sounds, and therefore a loud sound might be stored in the pre-
perceptual memory store together with a preceding quiet sound, for normal hearers. However, there
seems to be an almost linear correlation between a sound’s intensity and its detection time, with
roughly 1-1.5ms shorter detection time per intensity increase of 1 dB. With typical segment duration of
about 70ms, even a sequence such as English [θɔ] (the quietest sound followed by the loudest), with a
28dB difference at the speaker’s lips (Fletcher 1953:86), the loudest vowel [ɔ] cannot fuse neurally
with the quietest consonant [θ], especially because the intensity of the vowel is built gradually. Hence
such fusion is irrelevant for normal hearers hearing speech.
namely that the arrival and storage of a new auditory image causes some **reshuffling** of the short-term memory and some impediment to the processing of the preceding auditory images, predicts some backward masking.

A few studies comparing target recognition in both backward and forward potentially masking environments (as well as a control environment) found effects of both forward and backward masking (poorer target identification in the presence of a masker), but also significant differences between the two types of non-simultaneous masking: Backward masking was found to have a stronger and a more lasting effect. These findings serve as evidence of the uniqueness of backward masking.

For example, Massaro’s (1973) study comparing forward and backward masking of tone-patterns by tones reported similar poor identification of tone-patterns with both adjacent forward and backward tone maskers, but even the slightest interval between a preceding (forward) masker and the target resulted in almost optimal identification, which was not apparent for a following (backward) masker until very long target-masker interval.

Very similar results were obtained in Repp’s (1975) study of dichotic masking of consonants by vowels, where poor target recognition characterised both forward and backward maskers presented immediately adjacent to the target. With longer intervals between masker and target, however, forward masking was ineffective, while backward masking faded only gradually as target-masker interval increased.

The study of vowel recognition in forward and backward tone-masker environments conducted by Dorman et al. (1977) consistently showed absolutely no forward masking effect, while showing a limited backward masking effect.

According to some studies, masking might occur even after target categorisation. Parsing the short-term memory into separate units means discrimination between
auditory images. Post-categorisation masking might result, at least according to Crawley et al. (1986), from mistaken reference to the (already categorised) similar masker instead of the (already categorised) target during non-auditory processing.

### 2.3.2.2 Masking Level and the Duration and Intensity of the Masker

The amount of reshuffling in the short-term memory depends on the amount of storage needed for the new auditory image. This amount of storage reflects the amount of excitation inflicted on the auditory nerves by the signal, depending on the responsiveness of the relevant nerves and on the intensity and duration of the signal. This is apparent in many studies of masking effects that show that louder and longer maskers inflict greater masking (many scholars even view the increment in loudness or duration of the masker as decrement in signal-to-noise ratio), for example:

- In Homick’s et al. (1969) study of backward masking of a tonal signal by noise, louder noise maskers (90dB SPL) presented at a given interval after the signal had a masking effect similar to quieter noise maskers (70dB SPL) presented at an interval which was 20ms shorter.

- In Repp’s (1975) study of dichotic masking of consonants by vowels, all experiments show that louder maskers (54dB SPL) result in poorer recognition of the target than quieter maskers (46 dB SPL), both in forward, simultaneous and backward masking, unless the masker contains acoustic cues which echo acoustic cues in the target. In the same study, longer vowel maskers (300ms) result in poorer recognition of the target than shorter vowel maskers (55ms).

- In Gordon-Salant’s (1986) study of backward masking of consonants by vowels in CV syllables, an increase in consonant intensity (louder target = relatively quieter masker) systematically resulted in a significant improvement
in target recognition (consonant identification). She also cites various other studies that show precisely the same tendency.

2.3.2.2.3 Masking and Target-Masker Categorical Similarity

Various studies show that, as long as the masker is not identical to the target (in which case the masker actually enhances the auditory features of the target and facilitates its recognition), masking is more effective when the masker and the target belong to the same auditory category (i.e. auditorily similar), than when they belong to different auditory categories:

- Crawley’s et al. (1986) study of noise or tone duration recognition with noise or tone maskers shows significantly overall better performance when masker and target are dissimilar (tone/noise or noise/tone) than when masker and target are similar (tone/tone or noise/noise).
- Loeb & Holding’s (1975) study, comparing tone-level identification in tone vs. noise backward masking environment reports significantly better tone recognition in noise masker environment than in tone masker environment.
- Repp’s (1975) study reports a more effective masking effect on stop identification by a different stop masker than a vowel masker (but if the stop masker and stop target are identical, target recognition is improved).
- Dorman et al. (1977) show that a real-speech [o] vowel-masker inflicts more effective backward masking than a synthesised two-formant masker on real-speech vowel targets.

2.3.2.3 The Plausibility, and Nature, of Backward Masking of Vowels

Every sound has a certain potential to backward mask a preceding sound. Backward masking is therefore an inherent property of speech. Speech, however, is by and large intelligible, which suggests that the masking potential of speech sounds is very
limited. As limited as it may be, some sounds essentially have more backward masking potential than others over certain target sounds, given the characteristics of backward masking.

To the extent that vowels can be backward-masked, a potential masker has to be (a) as nearer as possible, (b) as loud as possible, (c) as long as possible, and (d) similar vis-à-vis its auditory representation. Postvocalic sonorants (including glides and vowels) fulfil all these criteria to an extent that their potential to mask a preceding vowel is crucially greater than any other sound in any position.

A fundamental question is: Can vowels actually be backward-masked? After all, vowels are the loudest and most prominent speech-sounds, they typically have long durations, and they typically involve some co-articulation with a preceding sound so that a preceding sound might be a cue to vowel identity as much as the vowel itself (Fletcher 1953:61, also Dorman et al. 1977:495 and references therein).

The answer to this question is: If there are sounds which are almost as loud as vowels (e.g. sonorants), if the vowels are extremely short (e.g. short vowels in languages that have phonemic vowel length contrast), and if the vowels do not involve co-articulation with surrounding sounds (e.g. in languages that have robust phonemic secondary articulation), then vowels might be susceptible to backward masking. Backward masking would be effective especially if the vocalic inventory is dense and the masked vowel can be confused with another, auditorily similar, vowel.

Dorman et al. (1977) tackle precisely this question about the plausibility of vowel masking. In their studies, vowel targets are very brief (15.5 to 30 ms), and to a large extent, their results show that vowels are immune to masking: only marginally effective backward masking was attested and only with shorter vowel targets (15.5 and 20 ms) – 30ms-long vowels were perfectly immune despite their very brief duration. The
authors’ contention therefore is that vowels are, in general, not susceptible to masking. However, the authors’ experiments tested forced-choice vowel recognition from a set of only 3 English vowels which are almost maximally distant from one another, namely [i], [ɛ] and [ʌ]. Given only these 3 choices, it is not surprising that subjects performed very well even when the auditory representations of the vowels were severely masked. In fact, results from the various experiments in their study show the great extent to which the 20 ms vowels are susceptible to masking: In experiment II, the change of masker from a complex tone to real-speech [o] increased the relative population of masking-affected subjects from 30% to 50%, and decreased the performance of this population in the most extreme masking condition (no silence interval between target and masker) from 70% to 60% correct vowel recognition. In experiment III, the addition of the [i] vowel target to create a 4-choice task ([i]/[ɪ]/[ɛ]/[ʌ]) decreased the performance of the 33% masking-affected population from 52% to 42% correct vowel recognition in the most extreme masking condition. All these statistically significant tendencies imply that vowels can be masked to a crucial degree given the right masker and a sufficiently large vocalic inventory. Finally, their study identifies two distinct populations of listeners, those unaffected by masking (‘Nonmaskers’) and those affected by masking (‘Maskers’). In all their experiments, the ‘Maskers’ were about 40% of the whole population, which comprised only young people (university students) with no hearing impairment. Although a minority, 40% is definitely not a ‘pathological subsection’, and is an integral part of any population. Hence, if 40% of humans are potentially affected by vowel backward masking, then this potential is definitely an integral part of any speech community.

2.3.2.4 The Immunity of Vowels to Masking

Naturally, even if we assume that vowels can be effectively masked, there is no
reason to assume that all vowels are similarly susceptible to masking.

As Dorman et al. (1977) show, duration definitely plays a role: inherently longer vowels are less susceptible to masking than inherently shorter vowels. This is somewhat obvious, because inherently longer vowels result in a larger, more prominent, auditory image (see Massaro 1972:136 for a tone analogy). Alternatively, following Repp (1974:731), a sound with longer duration is perceived as louder than the same sound with the same intensity but shorter duration. Thus it is as if longer duration increases signal-to-noise (or target-to-masker) ratio, resulting in less susceptibility to masking.

In addition, in order for masking to be effective, target vowels need competitors to be mistaken for. Size and distribution of the vocalic inventory are crucial, as is exemplified in experiment III of Dorman et al. (1977), in which incorrect performance in the vowel recognition task rises gradually with the increase of the target options from 2 to 3 to 4 vowel qualities. As distribution in vowel systems with more than 4 vowels typically obeys the principles of maximal auditory distance (Lindblom 1986) and organisational symmetry (Boersma 1998:348-350), it is typically the size of the vocalic inventory that determines the auditory distance between adjacent vowel phonemes, with larger inventories resulting in vowel phonemes which are closer, more auditorily similar, and more susceptible to confusion as a result of masking. Conversely, if vowel quality is non-contrastive, confusion of vowel quality is impossible, in any masking condition.

Finally, the auditory images of certain vowels might themselves contain details which are unlikely to be overwritten. One auditory property, which characterises only certain vowels, is the centre of gravity effect (Chistovich et al. 1979). When two formants are close enough to one another (within a distance of 3 bark), they form a
single, more intense, auditory prominence - a ‘super-formant’ - which is perceived in a frequency range between the two acoustic formants. In auditory tasks involving adjustment of a single tone to match a double-tone stimulus, subjects typically adjust the single tone to a frequency between the two tones if the distance between the two tones is 3 bark or less, and adjust the single tone to a frequency similar to one of the two tones if the distance is more than 3 bark. This single prominence is a very high concentration of energy in a small range of frequencies, resulting in very intense excitation of specific auditory nerves, and it is plausible that the resulting auditory image is so well defined that it would resist masking to a great extent.

Following Stevens (1998:266-268), and Hoemeke & Diehl (1994), among others, the ‘centre of gravity effect’ is an inherent property of high vowels, as the fundamental frequency and the first formant form a single prominence. Hoemeke & Diehl (1994) mention other sources with regard to similar effects of high front vowels, as the second, third and fourth formants are close enough to form yet another single prominence, and of low back rounded vowels (and pharyngeal approximants as well), for which the first and second formant form a single prominence.

This comment on the role of ‘centre of gravity effect’ on vowel recognition is written in a post-hoc view of the experimental study which is reported later in this thesis. I am not aware of any attempt to compare vowels with regard to immunity to masking in general, and to the role of the ‘centre of gravity effect’ in particular. However, consistency of argumentation, as well as caution, should be maintained at all stages: if certain (relative or absolute) auditory features of sound A can make it a more effective backward-masker, then certain inherent auditory features of sound B might make it immune to backward masking from sound A.
2.3.3 Co-articulatory Colouring, Backward Masking, and Syllabification

Both regressive co-articulatory colouring of vowel quality and backward masking inflicted by a postvocalic sonorant might impede the auditory perception of vowel quality. It might seem out of context to discuss the effect of syllabification on the amount of impedance since syllabification, at least among phonologists, is typically regarded as a linguistic, high-level process which typically interacts with other linguistic high-level processes and not with low-level processes. However, studies on auditory perception provide categorical evidence for low-level correlates of syllable and syllabification which might crucially interact with the low-level effects discussed above.

2.3.3.1 Auditory Low-Level Correlates of the Syllable

Quasi-syllable auditory bias is attested already in Massaro’s (1970, 1973) studies of backward masking, in which the backward masker typically loses its effectiveness, if presented 250ms or more after the onset of the target. In speech, vocalic material carries most information about pitch contour (intonation), vowel quality and place of articulation (in the transitions from and to vowels) of stops and nasals, which are the most common sounds in language and the earliest to acquire. Vowel onsets are therefore the speech correlates to Massaro’s tone onsets, and are the acoustic events that trigger reshuffling of the short-term memory (see also Greenberg 1996 for vowel onset as the major trigger for auditory responsiveness). Given this, then an interval of 250ms between consecutive vowel onsets is the optimal compromise between efficiency (conveying as much information as possible in a given period of time) and intelligibility (avoiding masking effects). As the interval between consecutive vowel onsets is roughly identical to the interval between consecutive syllables, and as 250ms is indeed a typical syllable duration, then typical syllable construction seems at least to conform to this low-level auditory constraint, if not actually be driven by
Huggins’ (1975) experiments on ‘shadowing’ of temporally segmented speech (the subject is trying to repeat aloud the original speech stream, which is presented spliced by silence intervals) provide evidence for a short-term memory buffer of 180ms: Given constant 200ms silence intervals, shadowing performance starts degrading when speech intervals are shorter than 180ms (and the shorter the speech intervals, the worse the performance). Huggins argues that, in temporally segmented speech, the long silence intervals degrade intelligibility (and shadowing performance) only once the short-term memory is not optimally exploited for storing the speech signal, that is, when the short-term memory contains additional silence. Hence the length of the short-term memory buffer correlates with the shortest speech interval in which shadowing performance is still normal, i.e. 180ms.

Other results in Huggins’ experiment strongly reinforce this claim: Given constant 63ms speech intervals, ‘shadowing’ performance is good as long as the silence intervals are shorter than 63ms. Performance degrades as the silence intervals are lengthened up to 125ms, and from then on, performance rates is rather bad but more or less constant despite further lengthening of the silence interval. Huggins argues that the connectedness of temporally segmented speech is fully recovered as long as

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3 Syllable duration roughly correlates with the number of segments in the syllable, and the reader might therefore object to the generalisation about universal syllable duration, because different languages permit syllables in different sizes, and hence different durations. It is a fact, however, that even in English, which is considered as one of the languages enabling the most complex, heaviest and time-consuming syllables, over 80% of the syllables in speech have a CVC or even simpler structure (Greenberg 1996:7). Lehiste (1970:52) mentions studies that show that, in normal speech rate in English, there are 4.4-5.9 syllables per second, that is, 169-227ms per syllable. However, from data provided in Greenberg (1996) it may be inferred that about one third to one half of the syllables in English discourse pertain to the closed class of mono-syllabic, unstressed-to-weakly-stressed function words, which occur very frequently and might involve different recognition strategies (for example, in English and in many other languages, they are easily recognised even under substantial reduction to a single consonant, e.g. [ŋ] for and in English). It is reasonable that such syllables are among the shortest in discourse, and that they lower the average syllable length. For syllables pertaining to non-functional words, the average duration is probably longer, between 220-250ms.
each two consecutive speech intervals is fully contained in the short-term memory at some stage (63ms of speech + 63ms or less of silence +63ms of speech ≤ 189ms); partially recovered as long as, while one speech interval is fully stored, a portion of the consecutive speech interval is also stored; and can no longer be recovered if the short term memory cannot store both one full speech interval and at least a portion of the following speech interval (63ms of speech + 125ms or more of silence ≥ 188ms). Hence, the short-term memory buffer is about 180-200ms.

Assuming (following Massaro 1973) that the optimal interval between vowel onsets is 250ms, that the short-term memory buffer is 180-200ms long, and that silence or quasi-silence (during voiceless or voiced stops respectively) is an uninformative acoustic event that audition easily dispenses with, then there emerges a clear low-level auditory correlate to the typical syllable: About 180ms of informative rhyme, occupied mostly by a vowel, preceded by 70ms of uninformative syllable onset, occupied mostly by a stop.

If these properties of the low-level auditory system are so strongly correlated with syllable typology, then, given that there seems to be no motor constraint on most consonant sequences (e.g. Berber) or vowel sequences (e.g. Hawaiian), the syllable and syllabification are probably the consequences of these properties: The human auditory system prefers to hear a signal whose nearest articulatory equivalent is a sequence of stop-vowel (or vowel-stop) units. Human speech generally adheres to this preference of the auditory system, as is evident from the fact that stop-vowel is the most prototypical and least marked syllable-structure cross-linguistically. As a result, the auditory system is likely to be tuned to capture syllables.

Greenberg(1996) pursues this notion, claiming that humans primarily hear syllables, rather than consecutive sounds. He develops a hypothesis that speech-sound
perception is performed by two parallel processes, namely a primary process of coarse windowing of the signal, roughly 200-250ms long, which elicits syllables, and a secondary process of fine grained windowing of the signal, roughly 40ms long, which elicits segmental and sub-segmental details from the syllable.

If humans roughly hear syllables and auditory inter-segment relationships are roughly restricted to intra-syllabic processing, then an auditory inter-segment relationship such as backward masking of a vowel by a following sonorant is likely to be more effective within a syllable (i.e. when the sonorant is in coda position) than across syllable boundaries (i.e. when the sonorant is the onset of the following syllable)\(^4\).

There is some complication with regard to ambi-syllabic intervocalic sonorants: On the one hand, if humans strictly perceive syllables, then an ambi-syllabic sonorant (or any ambi-syllabic consonant, singleton or geminate), is heard twice, once in the preceding syllable and once in the following syllable. On the other hand, the partition of a single sound, which essentially does not contain any auditory cue for partition to two separate entities within it, is senseless. I therefore assume that an ambi-syllabic consonant is perceived as a single sound within a single domain. Furthermore, the universal syllabification of a VCV sequence is V.CV, that is, the inter-vocalic consonant is first and foremost the onset of the following syllable, and only once this onset-requirement is satisfied, the intervocalic consonant may and may not serve as the coda of the preceding syllable. Thus, if humans perceive syllables also in lower

\(^4\) The reader might ask: If humans hear syllables, then why should an inter-segmental property such as backward masking be effective? The answer is that (a) masking can be effective in the sub-syllabic ‘fine grained process’, (b) the hypothesis that humans can hear syllables doesn’t necessarily imply that humans always hear syllables, and (c) human perception is unlikely to operate like a computer programme whose tasks are hierarchically separated, with the output of one task as the input of the other. It is more plausible that the various tasks involved in perception operate in parallel, using the same resources. That the theoretical strict hierarchy is violated is exemplified in linguistic domains of research such as syntax-phonology interface, syntax-pragmatics interface etc. and the theory of lexical phonology, with cyclic interaction between phonology and morphology and no hierarchy between them.
levels of audition, I assume that an ambi-syllabic intervocalic consonant is perceived with the following syllable, and that its ambi-syllabicity is recognised only at a later cognitive stage. For example, if duration plays a role in hetero-/ambi-syllabicity judgements, as would be the case in singleton/geminate contrast, a higher level duration comparison with the long-term memory image of the particular consonantal onset would elicit the exaggerated onset duration in the case of a geminate, and would take care of its recognition as geminate and as ambi-syllabic. I therefore assume that an ambi-syllabic intervocalic geminate sonorant (or any consonant) is not perceived as tauto-syllabic with the preceding vowel in the low-level stages of audition, with a resulting decrease in its backward-masking potential.

2.3.3.2 Syllabification and Vowel Colouring

Even if the original bias towards syllabification and the universal syllable type is auditory, it must have shaped the properties of the articulatory system. Indeed the syllable plays a key role in phonological theory, which typically focuses on speech production rather than perception. It is reasonable to hypothesise, for example, that the motor instructions to the speech organs are syllable-biased, and one of the consequences is that co-articulation would be more robust syllable internally than across syllables. More specifically, it is predicted that co-articulatory effects of vowel colouring by a following sonorant would be stronger when the sonorant is tauto-syllabic with the preceding vowel, than when the sonorant is hetero-syllabic, that is, forming the onset of the following syllable.

Partial empirical support to the latter specific hypothesis is found in Lehiste’s (1964) study of laterals in American English. According to her study, vowel colouring (atypical formant values) by a following lateral is most effective when the lateral syllable final, less effective when the lateral is ambi-syllabically intervocalic, e.g. when
a lateral-initial or vowel-initial suffix follows a word final lateral, and least effective when the lateral is hetero-syllabically intervocalic, e.g. when a lateral-initial suffix follows a word-final vowel (Lehiste 1964:41). Although such behaviour is not attested for the rhotic in her study⁵, there are other facts concerning the English rhotic which reflect a similar behaviour at least in an earlier stage of the language: Certain pre-rhotic vowel contrasts are present if the rhotic is hetero-syllabic with the vowel, but are neutralised if the rhotic is tauto-syllabic with the vowel. Thus, whereas only the eight vowels [i e a o u æ ø] contrast before syllable-final rhotic (in *mere, mare, bar, more, moor, hour, hire, her*, respectively), as many as 13 vowels [i ɪ e ɛ æ o u ο ø] contrast before an intervocalic rhotic (as in *hearing, mirror, error, Harry, barring, glory, boring, jury, dowry, hiring, hurry* respectively). Neutralisation before [ɪ] seems to have taken place as a result of the substantial colouring effect of the [ɪ], which involves retroflexion, labialisation and pharyngealisation (Ladefoged 1975:78). In Scottish English for example, where the rhotic is an alveolar trill or flap, with some velarisation or pharyngealisation but nothing as dramatic as [ɪ], all vowels contrast before the rhotic (Wells 1982:407-408). Thus, if regressive vowel [ɪ]-colouring is historically responsible for the neutralisation tauto-syllabically, the more marginal neutralisation hetero-syllabically (with intervocalic [ɪ]) probably stems from more limited [ɪ]-colouring in the latter case⁶.

⁵ Her study of the English rhotic seems incomplete, because whereas she seems to have aimed at providing acoustic data on all the allophones of the lateral and rhotic and as well as data on the allophones of all vowels preceding and following the lateral and following the rhotic, data for words such as *mirror* or *glory* are not reported.

⁶ Unless, of course, backward masking also played a role here. Despite identical regressive vowel colouring by both syllable-final [ɪ] and intervocalic [ɪ], neutralisation was more robust in the former case as a result of stronger backward masking in the tauto-syllabic construction. I leave this question open.
2.3.3.3 Syllabification Effect: Summary
The hypothesis is that both backward masking and vowel colouring should be more robust when the postvocalic sonorant is tauto-syllabic with the vowel (i.e. in coda position) than when the sonorant is hetero-syllabic (i.e. the onset of the following syllable). Hence, the impediment to vowel perception resulting from the presence of a following sonorant is substantially increased by vowel-sonorant tauto-syllabicity.

2.4 The Blurring Effect of Sonorants on Preceding Vowels
The hypothesis put forward in this thesis is that post-vocalic sonorants inflict a blurring effect on a preceding vowel, i.e. vowel quality is perceptually blurred in a pre-sonorant position. On a continuum of the precision of vowel recognition as a function of a following consonant, there is a categorical, steep difference between the relatively good recognition of pre-obstruent vowels and the poorer recognition of pre-sonorant vowels.

The two separate auditory effects discussed, i.e. auditory colouring as a result of co-articulation, and backward auditory masking, are essentially cumulative, and it is beyond the remit of this thesis to determine which of the two effects is more effective in the blurring. The elaborated discussion of the backward masking effect, in contrast with the briefER discussion of the colouring effect, reflects only the fact that masking has hardly ever been considered as phonologically relevant. The current attempt to introduce auditory masking - which has up until now interested only behaviour-psychologists, speech-technologists and hearing-pathologists - into phonological theory, deserves much more justification than the auditory colouring effect, which had been recognised by linguists (typically phoneticians and experimental phonologists).

As mentioned earlier, vowels and glides are predicted to exert a similar and even
greater *blurring effect* over an immediately preceding vowel. I believe this is indeed so, and that it plays at least some part in the universal synchronic and diachronic instability of diphthongs in the world languages. However, it is again beyond the remit of this thesis to compete with intuitive articulatory-based accounts or even auditory-based accounts for phonological phenomena involving diphthongs.

### 2.5 The Linguistic Relevance and Implications of the *Blurring Effect*

#### 2.5.1 The Linguistic Relevance of Auditory Properties

It is now appropriate to discuss the following question: Presuming that indeed, sonorants inflict an auditory *blurring effect* on immediately preceding vowels, does this auditory effect play any role in the linguistic system? How exactly is it incorporated into phonology? What are the systematic outcomes of this effect in the world’s languages?

Part of the answer has been given by various recent developments in phonological theory. The role of the listener, of perception, of audition, has been receiving more attention from formal phonologists in recent years (e.g. Flemming 1995, Boersma 1998), as opposed to the strictly articulatory orientation, which dominated since the days of SPE and through most auto-segmental theories of the 70’s and 80’s. This rise in the interest in the role of the listener is the particular manifestation of a more general, important development of growing interest in the **function** of phonological processes. this is perhaps best reflected by the ever growing popularity of Optimality Theory (OT - Prince & Smolensky 1993), in which all grammatical processes serve a purpose, i.e. the satisfaction of a grammatical constraint.

Furthermore, phonologists are increasingly recognising the role of the listener in grammar, and, broadly speaking, this role can be termed the ‘minimisation of perceptual confusion’ or the ‘maximisation of recognition’ (Boersma 1998:2).
2.5.2 The Blurring Effect and Language Acquisition

The hypothesised blurring effect is counter-perceptual, in the sense that it increases the probability of perceptual confusion. However, its potential degradation of perception is not necessarily linguistically relevant. After all, normal connected speech in general should be regarded as blurring. Sounds, syllables and even whole words are reduced, merged or sometimes omitted altogether. From low-level auditory parsing, through lexical mapping to high-level logical inference, these robust incidentals are more counter-perceptual than positional adjacency of one sound to another. Yet the reconstruction capabilities of a native listener seem to overcome these perceptual obstacles effortlessly. Once there are sufficient auditory, lexical, syntactic and pragmatically cues, the meaning is reconstructed, and the listener ignores deviations from the grammar, which are embedded in the signal. As these deviations are ignored, they seldom have any impact on the grammar of the listener or the speaker. In the utterance [ˈspoukə`resa] (I spoke with her on the cellular phone), the perceptual obstacle, resulting from the auditory blurring inflicted by the postvocalic syllabic extra long [l] on the preceding stressed vowel [ɛ] in cellular is negligible compared to the undershooting of all five function words, yet the sentence as a whole is perfectly intelligible to all native speakers of English. It is therefore unlikely that the blurring effect has any implications on the verbal behaviour of adults.

In fact, certain studies even show that a hypothetically blurring context actually facilitates recognition for adults. Thus, Krakow et al. (1988) show that pre-nasal nasalised vowels (i.e. both colouring and masking effects) are perceived by adult English speakers in a manner similar to the perception of oral vowels, whereas the perception of context-free nasalised vowels (only colouring) is degraded. However, the role of long-term memory in general, and of previous linguistic experience in
particular, in perception is central to any perception theory: once an English speaker establishes that preceding a nasal, a vowel has a particular auditory image, or more properly, establishes the sound of the specific vowel-nasal combination, then she uses this stored auditory image as reference and categorises a vowel-nasal sequence correctly, especially if the word itself sounds familiar and the utterance sounds logical. It is almost only at the stage of very sparse long-term memory and linguistic experience, when the child acquiring the language has virtually very little to compare a novel utterance with, that the blurring effect might come into play. I can only prosaically hypothesise, and I believe that there exists no study that can either support or refute this hypothesis, that the overall responses of young infants to words in casual utterances are more random in cases of vowel-sonorant sequences. The immediate consequences are either more repetition of the utterances, including more careful, louder, longer repetitions, or delayed acquisition of such words with a ‘noisier’ auditory representation. If the final auditory representation acquired differs from the auditory representation of the adult, then it is established that the blurring effect can play a role in the linguistic system.

2.5.3 The Blurring Effect and Language Typology

The theoretical account for of certain phonological alternations in Irish which is presented in chapter 4, is an attempt to incorporate the blurring effect into the core of the grammatical system, as a constraint that motivates a number of systematic phonological alternations.

If indeed the blurring effect is part of the perception grammar, it is likely to be manifested grammatically across languages and to have diverse cross-linguistic implications. There is little doubt that the co-articulatory colouring effects of postvocalic sonorants, which are very common, have cross-linguistic implications,
like historical merger or quality neutralisation of pre-sonorant vowels (e.g. rhoticised short vowels in English, nasalised vowels in French). However, it is quite difficult to find cases in which it can be claimed that it is the *blurring effect* per-se, including its backward masking component, which is responsible for phonological alternations, rather than simply co-articulatory colouring effects. On the other hand, the co-articulatory effects differ from one sonorant to another, and depend on the precise manner of articulation of the sonorant. Therefore, phonological alternations involving all sonorants as a natural class are not likely to result only from co-articulatory effects. Moreover, as it is the acoustic features of substantially greater intensity and formant-dependency that define the natural class of sonorants, phonological alternations that involve sonorants as a class are most likely to stem from these acoustic features and their auditory correlates. The backward masking hypothesis stems directly from these common characteristics of sonorants, and I suggest that a phonological alternation that involves a sequence of a vowel followed by a sonorant not belonging to any particular manner of articulation (e.g. nasal, lateral, trill, approximant), is related to the *blurring effect* and to backward masking and not only to co-articulatory colouring.

There can be various kinds of universally attested phonological alternations that involve a sequence of a vowel and a sonorant: neutralisation of vowel quality, vowel deletion, vowel-sonorant metathesis and vowel lengthening, to mention just a few. As I have not yet made a thorough cross-linguistic survey of these phenomena and their circumstances, I refrain from suggesting at this stage that they are related to the *blurring effect*.

There is, however, one well-known case of a relationship between a vowel and a following consonant, with a particular behaviour of vowel-sonorant sequences, that, I
believe, is related to the *blurring effect*, namely the dependence of vowel length on the following consonant in American English. It is worthwhile elaborating on this matter in order to illustrate how indeed the *blurring effect* can be manifested cross-linguistically.

In American English, vowel duration depends on the following consonant. The classical experimental study of Peterson & Lehiste (1960) shows that with regard to their effect on the duration of a preceding vowel, consonants in English are divided into five groups: Voiceless stops (plosives and affricates), voiced stops (plosives and affricates), voiceless fricatives, voiced fricatives and sonorants.

The hierarchy among these groups with regard to their lengthening effect on a preceding vowel is as follows (from least to most lengthening):

\[
\text{(2.1)}
\]

\[\text{Voiceless stops} < \text{voiceless fricatives} = \text{voiced stops} < \text{sonorants} < \text{voiced fricatives}.\]

The longer duration before voiced obstruents, relative to the corresponding voiceless obstruents, is, of course, an instance of the Vowel Length Effect (VLE), a nearly true language universal. Kluender et al. (1988) neatly refute all previous articulatory-based accounts of the VLE, and suggest an auditory-based explanation for the VLE of voiced obstruents compared to voiceless obstruents instead. According to their account, the longer vowel conspires with the shorter duration of the following voiced obstruent in order to enhance this obstruent’s voiced quality. As voiced obstruents are universally typically shorter than their voiceless counterparts, a longer vowel enhances the shorter duration of a following obstruent and makes it sound even shorter, and therefore obligatorily voiced.

The longer duration before fricatives relatively to the corresponding stops in the same voicing group is probably related to the fact that the transition from a vowel to a stop
can involve a ballistic and therefore abrupt movement of the articulator, but the transition from a vowel to a fricative cannot, because the critical aperture of fricatives obliges a gradual and hence slower movement of the articulator.

As for sonorants, neither enhancement of the voicing contrast nor the gradualness of the movement of the articulator can account for the longer duration of a preceding vowel: They neither involve voicing contrast nor a non-ballistic articulator movement (with the exception of [ɭ])⁷. If the voicing-contrast VLE and the ballistic vs. gradual articulator movement are the only considerations determining the duration of the vowel before a certain consonant or consonantal class, there is no reason that most sonorants would not pattern with voiceless stops. In Swedish, for example, this seems to be the case: Lehiste (1970:27) cites Elert’s (1964) study on vowel length in Swedish, according to which vowels are indeed longer before [d] and before [s] than before [t], in agreement with the VLE and the gradual vs. ballistic articulator movement factors, but is actually shorter before [n] than before [t].

If, however, the blurring effect is also a determining factor in vowel duration, in the sense that the vowel lengthening is a mechanism that enhances the auditory image of the vowel thus reducing its susceptibility to blurring, then the relatively long duration of pre-sonorant vowels in American English can be explained⁸.

This informal account, if in any way plausible, suggests that, as sonorants as a group

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⁷ In the case of [ɭ], the central closure is stop-like, and the lateral apertures are facilitated by the retraction and lowering of the tongue body, resulting in the ‘dark’ velarised [ɭ] in American English. Nasals are, of course, identical to stops with regard to their articulator movements. Although [ɭ] does involve a gradual articulator movement, the fact that vowel duration is actually shorter before [ɭ] than before nasals implies that the abrupt vs. gradual articulator movement does not play an important role in the duration of a pre-sonorant vowel in English.

⁸ In an earlier version of this section I tried to explain the longer duration of vowels before fricatives as compared to stops, and even duration differences among the various pre-fricative environments, as yet another manifestation of backward masking, assuming that fricatives do have some backward masking potential, smaller than that of sonorants. However, whereas there is some rationale in such an account, the gradual articulator movement in the case of fricatives seems more compelling.
motivate the lengthening of a preceding vowel, the *blurring effect* might be linguistically relevant, and if other languages behave in a manner similar to English in this sense (e.g. Spanish, see Lehiste 1970:27, and Turkish, see Barnes 2001), then there is at least one largely attested manifestation of it.

2.5.4 **The Linguistic Relevance of the Blurring Effect – Conclusion**

Given that co-articulatory effects of sonorants on preceding vowels are linguistically relevant, then once there are substantial reasons to assume that auditory backward masking is linguistically relevant as well, the *blurring effect* as a whole becomes linguistically relevant. The inevitable question, of course, if both components of the *blurring effect* are linguistically relevant and if they are the only components of the *blurring effect*, is why bother studying it as a unified property of linguistic perception, instead of analysing each of the two components separately?

While I believe there is full rationale behind this question, I also think that the answer comes directly from the history of articulation-based phonological theory: The successful, almost universally accepted classification of sounds into articulatory features never managed to account for all typological facts that relate directly to these features. Such a case is ‘fugitive [g]’ (Boersma 1998:384-386). It is well known that the consonant [g], while common among languages, is also frequently subject to systematic avoidance by various methods.9

What matters for us here is that, although [g] can be classified as voiced-velar-stop (or, more formally, as [+consonantal, -sonorant, DORSAL, +voice, -continuant, +high, +back]), there is nothing that stems directly from any of these features alone that can explain the typical ‘fugitiveness’ of [g], even if some of these features

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9 Boersma raises this example in order to show how phonological processes are target-driven, and more concretely, given that the target is ‘to avoid [g]’, how languages actually find various unrelated ways to achieve this target.
actually play a role in this tendency. It is only their combination, that is, the [g]-
gesture itself comprising of full closure at the velum during vocal-chord vibration,
which makes this sound disfavoured: If the supra-glottal space, whose air pressure is
critical for enabling vocal-chord vibration, is both very small and fully sealed, its air
pressure increases dramatically at a limited influx of air, and vocal-chord vibration
stops, resulting in natural passive devoicing, which is self-destructive in the case of
a voiced obstruent. Thus, one can investigate stops, or voiced obstruents, or velars,
but none of these investigations by itself can explain the ‘fugitive’ nature of [g].
Similarly, upon the incorporation of audition and perception into grammatical theory,
it is plausible that only the combination of the two hypothetical auditory features
[+backward colouring] and [+backward masking] makes the blurring effect so
powerful (if it is indeed powerful), with substantial typological implications.

2.6 Summary
This chapter developed the hypothesis that sonorant consonants inflict an auditory
blurring effect over a preceding vowel, that is, the auditory neural representation of a
vowel is very likely to be perceived incorrectly. The rationale behind this hypothesis
is the combination of co-articulatory backward colouring of vowel quality
(nasalisation, ‘rhoticisation’, displaced or gradually transient position of the tongue
body), and of the high backward masking potential of sonorants over preceding
vowels. Backward masking and its linguistic relevance, as well as the linguistic
relevance of the blurring effect in general, were elaborated, as they are the innovative
ideas, linguistically speaking, that might, and should invoke some scepticism from the
typically phonologically-oriented reader.
3 Vocalic Alternations in Irish

This chapter presents phonological data from Irish, which, it will be claimed in later chapters, are directly related to the *blurring effect* hypothesis discussed in the previous chapter. This chapter sets off with a sketch of the basic phonological system of Irish, and continues with a survey of certain phonological alternations in the various dialects. The description of the data is always accompanied by considerations relevant to the *blurring effect* hypothesis, which are needed for the theoretical account presented later.

3.1 The Dialects of Modern Irish

Scholars commonly divide twentieth century spoken Irish into three major dialects: The Southern or ‘Munster’ dialect(s), spoken in counties Waterford, Cork, Kerry and South Clare, the Western or ‘Connacht’ dialect(s), spoken in counties Galway and North Clare, and the Northern or ‘Ulster’ dialect, spoken in county Donegal. The distinct dialect of county Mayo is clearly a bridge between the Western and the Northern dialects, sharing many features with both.

Each dialect is further divided into local sub-dialects, yet the major ternary division holds, especially with regard to linguistically significant distinctions.

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10 My concern is with the dialects of the early-to-mid 20th century when most Irish dialectology fieldwork was carried out, rather than contemporary dialects. The contemporary dialects have experienced enormous changes, mostly as a result of the fact that in the last few decades all dialects have been in a state of complete bilingualism, as all native speakers of Irish are also native speakers of English, using English on a daily basis. However, this was not the case two or three generations ago. During the first half of the twentieth century, the *Gaeltachtaí*, i.e. the officially defined Irish-speaking districts, were still territorial pockets in which Irish was the everyday language. Although the vast majority of the residents in these areas already had a good knowledge of English and bilingualism was constantly spreading, Irish monoglots still existed, and for many others, English was clearly a second language acquired at a later stage. As transportation and mass-media (in both English and Irish) were not as widely available as they are today, and as those *Gaeltacht* were typically remote and isolated (both from one another and from centres of larger populations), each such *Gaeltacht* was a relatively isolated linguistic community, with its own linguistic characteristics, i.e. its own distinct dialect of Irish.
3.2 Basic Phonology of Modern Irish

3.2.1 Consonants

3.2.1.1 The Basic System

Following are the consonants of Irish\textsuperscript{11}. Some of the consonants are absent in certain dialects, as will be discussed later.

Table 3.1: The consonant system of Irish

<table>
<thead>
<tr>
<th></th>
<th>labial</th>
<th>lamino-inter-dental</th>
<th>dental, alveolar, post-alv.</th>
<th>dorso-palato-alveolar</th>
<th>(post-) palatal, velar</th>
<th>glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>stop/affricate</td>
<td>p\textsuperscript{v} b\textsuperscript{v}</td>
<td>{t\textsuperscript{v} d\textsuperscript{v}}</td>
<td>t\textsuperscript{v} d\textsuperscript{v}</td>
<td>{t\textasciitilde d\textasciitilde}</td>
<td>k g c j</td>
<td></td>
</tr>
<tr>
<td>fricative</td>
<td>f\textsuperscript{v} v/w f\textsuperscript{i} v\textsuperscript{i}</td>
<td>s</td>
<td>j</td>
<td>x y</td>
<td>c j</td>
<td>h</td>
</tr>
<tr>
<td>nasal</td>
<td>m\textsuperscript{y} m\textsuperscript{l}</td>
<td>N\textsuperscript{y}</td>
<td>n\textsuperscript{y} n\textsuperscript{l}</td>
<td>N\textasciitilde</td>
<td>f\textasciitilde</td>
<td>n</td>
</tr>
<tr>
<td>lateral</td>
<td>l\textsuperscript{y}</td>
<td>l\textsuperscript{v}</td>
<td>l\textsuperscript{\textasciitilde}</td>
<td>l\textasciitilde</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rhotic</td>
<td>r(r) r\textsuperscript{\textasciitilde}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In each cell consonants in the upper row belong to the ‘broad’ or velo-uvularised series, and consonants in the lower row belong to the ‘slender’ or palatalised series.

The upper case consonants are ‘tense’ coronal sonorants, and are distinct from the corresponding lower case consonants (‘lax’ coronal sonorants). The ‘tense’ coronal sonorants are longer, more peripheral, and involve increased muscular tension, compared to their lax counterparts. This distinction, as well as its status in the various dialects, is discussed in section 3.2.1.3 below.

The lamino-inter-dentals \{t\textasciitilde d\textasciitilde\} are Mayo and Northern variants of the lamino/apico-

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\textsuperscript{11} This is, of course, a generalisation. The consonantal system presented here is probably faithful to the Irish of the 17th century, when clear dialectal differences started to emerge.
dental/alveolars [t̪ː d̪̞ː] in most other dialects (Mac an Fhailigh 1968, Quiggin 1906).
The dorso-alveo-palatal affricates {tʃ dʒ} are the Mayo and Northern variants of the
post-alveolar stops [tɬ dɮ] in the other dialects (Mac an Fhailigh 1968, Wagner 1959,
Ni Chasaide 1999).
The long coronal trills (ɾ ɾ) are extinct in all contemporary dialects, but at least /ɾ/ was
present in the Northern dialect until recently, and is relevant to the discussion later.

3.2.1.2 Secondary Articulation and Immunity to Co-articulation
Most, but not all, of the consonants in Irish, involve phonetic secondary articulation,
which is manifested in [i]-like on-glide and off-glide in the case of palatalisation, and
In a manner typical of languages with robust secondary articulation, co-articulatory
effects of adjacent vowels on all consonants are minimal, and are practically non-
existent for consonants involving phonetic secondary articulation (Ni Chasaide &
Fealy 1991). For a phonological account of immunity of secondary-articulated
consonants to co-articulatory effects see Ní Chiosáin & Padgett (2001)\textsuperscript{12}. Given the
absence of co-articulatory effects of vowels and consonants, prevocalic consonants
are unreliable providers of auditory cues for the quality of following vowels in Irish.

3.2.1.3 Sonorants and Lax/Tense Contrast

3.2.1.3.1 The Nature of the Lax/Tense Contrast and its status
With the exception of the dorsal nasals /ŋ ɲ/, all sonorants in modern Irish

\textsuperscript{12} As secondary articulation in Irish developed historically from regressive assimilation of the
consonant to the following vowel (McKone 1994:84), and as its fully phonemic status became robust
only during the 13th century (McManus 1994:346-347), it is most likely that, a few centuries ago,
phonetic secondary articulation was more robust than in contemporary Irish, perhaps in a manner
similar to Russian, with only negligible co-articulatory effects of adjacent vowels, if at all.
historically involved a lax/tense contrast, which stemmed from the singleton/geminate contrast that had been valid for all consonants in Old Irish. However, according to McManus (1994:351-352), the lax/tense contrast became irrelevant for the labial nasals as soon as the lax labial nasal approximants /v \~ v/ merged with the voiced labial fricatives /v(w) \~\~/, as early as the 13th century (with marginal survival of ‘broad’ /v\~\~/ in the Northern dialect, see Ó Baoill 1996:6-7). As for the rhotics, it is widely accepted that the contrast involved a flap or short trill vs. a long trill, as in e.g. Spanish. This contrast is obsolete in all contemporary dialects, but this is a more recent development, as the Northern dialect still had this contrast in the beginning of the 20th century (Hughes 1994:623, Ó Baoill 1996:16), and free variation between long and short trill is still attested at present among older speakers of this dialect. As for the other coronal sonorants, the lax/tense contrast persisted, to varying degrees, to twentieth century dialects.

The original quantitative (singleton/geminate) nature of this contrast persisted for many generations, as can be easily attested by (a) simplifications of consonant clusters which resulted in geminate sonorants, at least in spelling, e.g. cland > clann ‘descendents, tribe’, Nodlaig > Nollaig ‘Christmas’, London > Lonnan ‘London’ (McManus 1994:354). Such simplifications are also apparent in borrowings from English, e.g. fuinneog, inneacs, g\~ell (‘window’, ‘index’, ‘yield’ respectively). (b) Extreme rarity of vocabulary items containing a lexically long (bi-moraic) vowel followed by a tense sonorant in coda position. This is predictable if the tense sonorant is geminate (moraic), given the universal bias against super-heavy (tri-moraic) syllables.

Nevertheless, there is also plenty of evidence that the nature of the lax/tense contrast among coronal sonorants was of qualitative nature, involving contrasts in both active and passive articulators. Following Breathnach (1994:234), as early as in Middle Irish there
have been cases of ‘double spelling’ of coronal nasals and laterals (i.e. \(nn, ll\)) before \(s\) and \(t\), e.g. \(millse\) instead of \(milse\) ‘sweetest’, \(muinntire\) instead of \(muintire\) ‘folks gen.’. To the extent that evidence from text is reliable, such spelling alternations are more likely to indicate qualitative (assimilatory) rather than quantitative change in these sonorants. In contemporary dialects that maintain a lax/tense contrast among coronal sonorants (i.e. the Northern and Western dialects), the contrast always involves articulatory difference. The following chart presents a more detailed comparison of precise articulation of coronal nasals and laterals, across a few sub-dialects from South to North\(^{13}\)\(^{14}\):

Table 3.2: Coronal laterals and nasals in various dialects

<table>
<thead>
<tr>
<th>Dialect</th>
<th>(l^\prime)</th>
<th>(l^\prime)</th>
<th>(l)</th>
<th>(u)</th>
<th>(n^\prime)</th>
<th>(n^\prime)</th>
<th>(n)</th>
<th>(n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ring</td>
<td>approximant / lamino-alveo-dental</td>
<td>apico-alveolar</td>
<td>lamino(?)</td>
<td>lamino(?)</td>
<td>lamino-alveolar</td>
<td>lamino-alveolar</td>
<td>dorso-post-palatal</td>
<td></td>
</tr>
<tr>
<td>West Muskerry</td>
<td>apico-dental</td>
<td>lamino-alveo-dental</td>
<td>lamino-dental</td>
<td>lamino-dental</td>
<td>lamino-alveolar</td>
<td>lamino-alveolar</td>
<td>dorso-post-palatal</td>
<td></td>
</tr>
<tr>
<td>Aran</td>
<td>apico-inter-dental</td>
<td>apico-post-alveolar</td>
<td>dorso-palato-alveolar</td>
<td>apico-dental</td>
<td>apico-post-alveolar</td>
<td>dorso-palato-alveolar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cois Fhairrge</td>
<td>lamino(?)-alveolar</td>
<td>apico(?)-alveolar</td>
<td>dorso-palato-alveolar</td>
<td>lamino-alveolar</td>
<td>apico(?)-alveolar</td>
<td>dorso-palato-alveolar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tourmakeady</td>
<td>apico-alveolar</td>
<td>lamino-dental</td>
<td>apico-alveolar</td>
<td>lamino-post-alveolar</td>
<td>apico-alveolar</td>
<td>lamino-alveolar</td>
<td>apico-alveolar</td>
<td>lamino-post-alveolar</td>
</tr>
<tr>
<td>Erris</td>
<td>apico-post-alveolar</td>
<td>lamino-inter-dental</td>
<td>apico-alveolar</td>
<td>lamino-post-alveolar</td>
<td>apico-alveolar</td>
<td>lamino-inter-alveolar</td>
<td>apico-alveolar</td>
<td>lamino-post-alveolar</td>
</tr>
<tr>
<td>Meenawania</td>
<td>apico-post-alveolar</td>
<td>lamino-inter-dental</td>
<td>apico-alveolar</td>
<td>lamino-post-alveolar</td>
<td>apico-alveolar</td>
<td>lamino-inter-alveolar</td>
<td>apico-alveolar</td>
<td>lamino-post-alveolar</td>
</tr>
<tr>
<td>Inishowen</td>
<td>apico-alveolar</td>
<td>lamino-inter-dental</td>
<td>apico-alveolar</td>
<td>lamino-inter-alveolar</td>
<td>apico-alveolar</td>
<td>lamino-inter-alveolar</td>
<td>apico-alveolar</td>
<td>lamino-inter-alveolar</td>
</tr>
</tbody>
</table>


\(^{14}\) The degree of gray background in each square roughly corresponds to the articulatory effort involved in the gesture. Effort and duration considerations will be discussed in section 3.2.1.3.2 below.
It is immediately evident that, if the contrast is present in the dialect, it involves an articulatory contrast in both active articulator (tongue blade or front of tongue body vs. tongue tip) and passive articulator (inter-dental or alveo-palatal vs. alveolar). This contrast may be summarised as [+apical-distributed] vs. [-apical+distributed].

Notice that the lax/tense distinction among ‘slender’ nasals in the Southern dialect is not real. In this dialect, the tense ‘slender’ coronal nasal simply merged with the ‘slender’ dorsal nasal.

3.2.1.3.2 Lax/Tense Contrast, Effort and Duration

As just demonstrated, some contemporary dialects of Irish still maintain the contrast between lax and tense coronal laterals and nasals. As this contrast is manifested identically among these dialects, it is probably representative of the state of affairs in these locations at times when Irish still covered a unified territory, a few centuries ago. This distinction is both articulatory (apico-alveolar vs. lamino-interdental for ‘broad’ coronals, and apico-alveolar vs. dorso-alveo-palatal for ‘slender’ coronals) and durational (short vs. long). The question of whether the contrast is quantitative or qualitative is by and large immaterial for our purposes, as both imply that the tense coronal sonorants are longer than their lax counterparts.

It is clear that tongue position in the case of lax coronal sonorants is near neutral, but

\[\text{\textit{\footnotesize{15}}}\] Most convincing is probably the fact that, according to De Bhaltdraithe (1945:41), the minority of speakers of the Cois Fhairrge dialect who are said to maintain the lax/tense contrast for ‘broad’ sonorants, articulate these sonorants in a manner identical to the articulation in the dialects of North Mayo and Donegal, that is, apico-alveolar vs. lamino-inter-dental. Conversely, De Búrca (1970:40) states that the lax/tense contrast among the ‘broad’ sonorants is at an advanced stage of neutralisation, which goes hand-in-hand with the less peripheral articulation of the tense members (dental rather than inter-dental). De Búrca does not mention similar neutralisation among the ‘slender’ sonorants, where the tense member is also non-peripheral, but such neutralisation is well attested in the very near dialect of Achill (Stockman 1974:335).

\[\text{\textit{\footnotesize{16}}}\] Notice that there is no contradiction between quantitative and qualitative nature of the contrast. For example, a light/heavy vowel contrast in many languages (e.g. English, German), also involves vowel-quality contrast (e.g. [i]/[i]). What matters for our point is that, whatever the contrast between lax and tense sonorants in Irish is or has been, it has always involved a duration contrast, with lax sonorants being shorter than the tense sonorants.
maximally displaced from neutral in the case of tense coronal sonorants: inter-dental
placement of the tongue blade is almost maximal tongue protrusion. alveo-palatal
placement for the front part of the tongue body (the dorsum) again involves maximal
displacement of the tongue\textsuperscript{17}. In contrast, if the contrast is absent, the articulation may
vary from apical to laminal, typically in the dental-alveolar region.

There seems to be a one-way causal relationship between the articulatory contrast and
duration and/or effort contrast. Both ‘broad’ and ‘slender’ tense coronal sonorants
involve substantial tongue displacement from neutral position, whereas displacement
for their lax counterparts is minimal. The direct relation between displacement and
effort is rather trivial (see Flemming 1995:14, Boersma 1998:149-151). Likewise
trivially, greater displacement, which is not compensated for by faster movement of
the articulator, involves longer duration.

In addition, the stricture of tense coronal sonorants involves much larger articulator
surface (tongue blade, front dorsum) compared to the articulator surface during lax
structure (tongue tip), and formation of this larger stricture is time consuming.

Finally, certain descriptions (e.g. Quiggin 1906:78-82, Sommerfelt 1922:48-51,73-76,
Mhac an Fhailigh 1968:41) of tense articulations mention particular pressure between
the articulators, as if the passive articulator (teeth, front-palate) absorbs some of the
kinetic energy created during the (radical) displacement of the tongue, that is, the
passive articulator plays an active part in stopping tongue movement, and this
stopping process is probably time-consuming, and definitely involves particular
effort.

\textsuperscript{17} This is of course untrue for laminal or apical alveo-palatal articulation. However, in practically all
descriptions of the dialects that maintain lax/tense contrast among the ‘slender’ coronal sonorants it is
mentioned explicitly that the tip and blade of the tongue are passive and are typically placed loosely
behind the lower incisors, and that the contact is made by the front part of the tongue body (e.g.
Additional evidence for the effort contrast between lax and tense sonorants comes from the phonological behaviour of word-initial lenition, a morphological and grammatical process of word-initial consonantal mutation attested in Irish. The following examples demonstrate one grammatical environment where word-initial lenition takes place, as well as its application for coronal sonorants (most examples are from the Northern dialect following Hughes 1994:622):

(3.1)

<table>
<thead>
<tr>
<th>Non-lenited</th>
<th>Lenited</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>béal</strong> ‘mouth’</td>
<td><strong>mo bhéal</strong> ‘my mouth’</td>
</tr>
<tr>
<td>[bʲːl]</td>
<td>[mʲə bʲːl]</td>
</tr>
<tr>
<td><strong>cos</strong> ‘foot’</td>
<td><strong>mo chos</strong> ‘my foot’</td>
</tr>
<tr>
<td>[kɔs]</td>
<td>[mʲə ƛɔs]</td>
</tr>
<tr>
<td><strong>léan</strong> ‘sorrow’</td>
<td><strong>mo léan</strong> ‘my sorrow’</td>
</tr>
<tr>
<td>[lʲːn]</td>
<td>[mʲə lʲːn]</td>
</tr>
<tr>
<td><strong>nasc</strong> ‘link’</td>
<td><strong>mo nasc</strong> ‘my link’</td>
</tr>
<tr>
<td>[nʲask]</td>
<td>[mʲə nʲask]</td>
</tr>
</tbody>
</table>

That consonant lenition involves effort reduction is well documented in Kirchner (1998), and the association of a tense-lax alternation with a stop-fricative alternation clearly points to effort reduction from tense to lax articulation.

Articulatory effort is phonologically marked. From the fuzziest phonological explanations using the term ‘ease of articulation’, to the most detailed calculations of effort and formalisation of ‘laziness’ or ‘counter-effort’ markedness constraints (e.g. Kirchner’s 1998 ‘LAZY’, Boersma’s 1998 ‘*EFFORT’), phonologists seem to agree that articulatory effort is disfavoured. In terms of Optimality Theory, effort can be preserved only by faithfulness constraints, whereas markedness constraints militate against it. A universal implication of this is that sounds involving particular articulatory effort are rarer, whereas sounds involving moderate effort are more common. The converse of the second part of the last statement is also true, that is, (universally) common sounds are likely to involve moderate effort.

In the case of coronal articulation, Brakel(1983:41) claims that apico-alveolar is the most common articulation universally, and hence least marked, but it is not clear
whether his apico-alveolar is a cover term including also laminal articulation, and
areas near the alveolus (dental, immediately post-alveolar). As there is no
implicational relationship between such articulations and the least marked apico-
alveolar articulation (e.g. there are languages whose coronal articulation is primarily
lamino-dental and not apico-alveolar, for example French and Spanish, see Delattre
1965:89-90), such articulations are probably equally unmarked and do not involve
extreme effort. Lamino-inter-dental and dorso-alveo-palatal articulations, on the other
hand, seem to be rather rare and to involve an implicational relationship with any of
the other coronal articulations mentioned above.
It is therefore not surprising that, in those dialects that do not maintain the lax/tense
contrast among coronal sonorants, the articulation of these sonorants will involve any
stricture within the unmarked range, that is, apical or laminal stricture, from right
behind the upper teeth to the immediately post-alveolar area, and the amounts of
effort and duration involved in such articulatory options vary from minimal to
normal, or even slightly increased.
In those dialects that maintain the lax/tense contrast, the tense variants always involve
maximal effort, duration and displacement. In those dialects, in accordance with the
principle of maximisation of distinctiveness of contrast (Flemming 1995:13 and
antecedent sources therein) the lax variants are restricted to an articulatory gesture
which is as distinct as possible from the tense variants. Given the peripheral
articulation of the tense coronal sonorants (inter-dental, alveo-palatal), it is not
surprising that lax coronal sonorants are limited to the least peripheral coronal
articulation, namely alveolar.
With regard to the relatively recently obsolete lax/tense contrast among coronal
rhotics, it is rather trivial that the lax flap involves both less duration and less effort
than the tense trill (see Lehiste 1970:30).

To summarise: The lax/tense contrast for coronal sonorants, whenever maintained, involves reduced vs. increased duration and effort contrast as a direct outcome of the articulatory gesture, independent of whether or not the contrast is quantitative (singleton vs. geminate).

3.2.1.3.3 Lax/Tense Contrast and Masking Potential

Recall from chapter 2 that the masker’s duration, in addition to intensity, plays an important role in the backward masking potential of a masker.

Whereas all sonorants in Irish supposedly have relatively high vowel-masking potential, longer sonorants should have higher masking potential than shorter sonorants.

As the tense sonorants in Irish are longer than their lax counterparts, it is predicted that the tense sonorants should have higher vowel-masking potential than the lax sonorants.

However, there are probably three, rather than two, levels of sonorant duration in Irish, and correspondingly, three levels in the hierarchy of vowel-masking potential of sonorants. Recall that the labial and back-dorsal nasals do not involve a lax/tense contrast, and duration does not play any active role in their distinct formation.

Therefore, since longer maintenance of stricture is effort-consuming (Boersma 1998:150), and since effort is phonologically disfavoured, the labial and back-dorsal nasals should not involve long durations as the tense coronal sonorants do. On the other hand, bilabial and back-dorsal stop stricture, similar to laminal stop stricture and unlike apical stop stricture, involve large surface contact of the articulators, whose formation and release are inherently time consuming. As a result, the bilabial and

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18It is not surprising, for example, that Catford (1970:327) excludes the bilabial, dorso-palato-alveolar, dorso-palatal and dorso-velar articulations, together with all laminal articulations, from the possible flap articulations. Catford (1970:322) distinguishes a flap from a stop merely by the ‘momentariness’ of the flap gesture and the ‘looseness’ of the articulators. As labio-dental, denti-labial and dorso-uvolar
back-dorsal nasals most likely involve duration, which is intermediate between lax coronal sonorants and tense coronal sonorants.

The duration and backward masking hierarchy of the Irish sonorants I propose is, therefore:

**Tense coronal sonorants >> Non-coronal nasals >> Lax coronal sonorants.**

### 3.2.1.4 Devoicing Effects of Voiceless Stops in Irish

A common feature of all dialects of Irish, or more correctly stated, of Gaelic (including Scottish Gaelic), is the strong aspiration of voiceless stops. All voiceless stops in Gaelic are post-aspirated both in stressed and unstressed syllables, except after [s] or [ʃ], with clear devoicing effect on a following vowel or sonorant. In addition, non-initial voiceless stops are also pre-aspirated to varying degrees across dialects, with extreme pre-aspiration in Scottish Gaelic yielding clusters such as [hp ht xk] (Watson 1994:664, Ó Baoill 1980, among others), and more moderate (but nevertheless present) pre-aspiration in Irish (Ní Chasaide 1999:113). This aspiration devoices a portion of a preceding sound, be it a vowel or a sonorant (Ní Chasaide 1979:67, Mhac an Fhailigh 1968:25, De Bhaldráithe 1945:42, Ó Cuív 1944:32, Breátnach 1947:50-54). As the duration of this pre-aspiration is more or less consistent for a given voiceless stop, then the shorter the sonorant the more effective the regressive devoicing by the following voiceless stop. As this devoicing effect is present in all dialects of Irish and Scottish Gaelic, it is reasonable to assume that it had been present in the language at least since the Early Modern period, before the flaps are, according to the same source, possible, there is essentially no motor problem with looseness of the lips or dorsum (or any articulator), and it is the ‘momentariness’, which is problematic. As ‘momentariness’ is by and large possible for most apical and sub-laminal articulations, impossible for laminal articulations, and for non-coronal articulations it is possible only if the passive articulator has very small surface (upper and lower incisors, uvula), we may safely infer that ‘momentariness’ of stricture entails small surface of articulator contact.
dialects were geographically split. The following oscillograms and spectrograms, performed on a recent recording of a speaker of a Northern dialect, demonstrate the heavy aspiration and the regressive devoicing effects of voiceless stops in Irish, compared to their voiced correlates. The spectrogram on the left is of the word *dailc* [d̪ˠalːc] ‘chunk’, whereas the spectrogram on the right is of the word *seilg* [ʃɛlːʃ]. Both words have roughly the same duration (about 450ms), and the durations of the lateral in both is roughly the same (about 90ms). Notice in the right spectrogram (a) the post-aspiration of the final voiceless stop, (b) the regressive devoicing effect of the voiceless stop on the lateral, with slight frication effect and substantial muting effect (notice the steep decline in intensity of the lateral, both in the oscillogram in the white line on the spectrogram).

**Figure 3.1: Oscillograms and Spectrograms of the words *dailc* and *seilg* uttered by a native speaker of the Gaoth Dobhair dialect.**

![Oscillograms and Spectrograms](image)

This devoicing effect is relevant in this instance, because the backward masking potential of a sonorant (or of any sound) is in direct relation to its intensity, and hence a devoiced sonorant, whose intensity is reduced, has less backward masking potential than a fully voiced sonorant, especially in the case of the lax coronal sonorants.
3.2.1.5 Consonants – Summary

The following are the characteristics of the consonantal system of Irish, which are relevant for the *blurring effect*:

- Consonants have secondary articulation and as a result vowels have very limited regressive (or progressive) co-articulatory effects over consonants. Hence the auditory quality of a consonant is a very weak cue for the auditory quality of an adjacent vowel, and perception of vowel quality depends **only** on the auditory quality of the vowel itself.

- There is a contrast between lax and tense coronal sonorants. This contrast is manifested in duration, and the tense coronal sonorants are significantly longer than the lax coronal sonorants. The duration of non-coronal sonorants is intermediate between the lax and tense coronal sonorants. As a sonorant’s backward masking potential directly relates to its duration, tense coronal sonorants have a higher masking potential than non-coronal sonorants, which have a higher masking potential than lax coronal sonorants.

- Voiceless stops are pre-aspirated and therefore regressively devoice sonorants. This devoicing effect results in a significant decline in the intensity of sonorants, which is most effective for short sonorants (lax coronal sonorants). As a sonorant’s backward masking potential directly relates to its intensity, such a devoicing effect reduces the backward masking potential of a sonorant.

3.2.2 Stress

In Irish, stress is predominantly word-initial. In the Northern dialect word-initial stress is the rule with (literally) a handful of lexical exceptions. This rule holds for the Western dialects, only with more exceptions. In the Southern dialect initial stress is the default option, but the stress system is complex and weight-dependent. The only
important matter for our purposes with regard to stress placement in the Southern dialect, as will become clear later on, is that stress always falls on the second syllable if the second syllable contains a long vowel.

On stress in Irish see Ó Siadhail (1989:28-34), Ua Súilleabháin 1994:479-482) and for theoretical account of the stress system of the Southern dialect see Green (1997). Following McManus(1994:343), word-initial stress was the state of affairs in Early Modern Irish as well.

3.2.3 Vowels

Making precise cross-dialectal generalisations over the vowel system is rather risky, because vowel quality is very susceptible to change. More concretely, as contemporary dialects differ from one another vis-à-vis their vocalic inventories, and as obviously there are no audible recordings of earlier stages of the language, there is no sense in attempting to specify a common vocalic inventory.

It is generally accepted that Irish distinguishes long vowels from short vowels, and that long vowels can always appear with their distinctive quality both in stressed and unstressed syllables. Short vowels have distinctive quality only in word-initial stressed syllables, and are target-less elsewhere. This was probably the case in all dialects in the Early Modern period (McManus 1994:344-345), and is the state of affairs in the Western dialect to this very day (Ó hUiginn 1994:549)

3.2.3.1 Long Vowels and Diphthongs

3.2.3.1.1 General Behaviour

All dialects of Irish have the following long monophthongs: [i: e: a: o: u:]. In the Northern

19 In the Southern dialect, stress shift to a non-initial syllable might result in an initial unstressed syllable with a short vowel, which partially retains its distinct quality (Ua Suilleabháin 1994:481). The behaviour of these short vowels is outside the scope of this thesis. In the Northern dialect, originally unstressed long vowels become short but retain partial vowel quality. They are discussed below.
dialect the low monophthong is typically realised as [æː]; there developed a contrast between [oː] and [ɔː] (or actually [ɔː]); and some sub-dialects also have the vowel [uuː].

In the Western and Southern Dialects the low monophthong is typically retracted and somewhat rounded [ɔː]20. In some Western and Southern dialects, e.g. Cois Fhairrge, the long monophthong [æː] also developed via compensatory lengthening of a short [æ] for loss of [h] or [ɣ], and was granted a phonemic status. The long monophthongs may appear in all consonantal environments, in both stressed and unstressed syllables.

In addition to the long monophthongs, all dialects also have the following diphthongs: [iə uə ai au]. Some Southern dialects have two additional, mid-to-high rising diphthongs (e.g. [œi œu] in Ring, [ei ou] in West Muskerry, see Breathnach 1947:23-25, Ó Cuív 1944:27-29). The distribution of diphthongs is constrained by the consonantal environment, and their occurrence in unstressed syllables is very rare.

As mentioned in chapter 2, inherently long vowels are hypothetically rather immune to the blurring effect, and are not the focus of our interest.

3.2.3.1.2 Long Vowels in the Northern Dialect

In contrast with the generalisations just mentioned about long vowels in Irish, long vowels are clearly disfavoured in the Northern dialect and are subject to certain distributional constraints.

In unstressed syllables vowels are never fully long. Following Ó Baoill (1996:2), there are, however, two distinct sub-trends within the dialect, with regard to treatment

20 Rounding of the low-vowel is never mentioned in the dialect descriptions, which typically use [æː] for the low back vowel. However, Ni Chiosáin (personal communication) confirms that this vowel is typically rounded in the Southern and Western dialects. Further evidence for the roundedness of this vowel comes from the common pronunciation of Irish words and names in Hiberno-English: Dáil [dail] (the Irish parliament), bord fáilte [bɔrdfəiltə] (the Irish Tourist Board), Seán [ʃən] (Seán – a man’s name, also Sean or Shawn in English spelling), Máire [mair] (Máire – a woman’s name, also Moira, Maura, Moya in English spelling).
of originally long vowels:

- In the southern sub-dialects of the Northern dialect (e.g. Teilinn), these vowels are ‘half-long’. They are merely shorter variants of long vowels in stressed syllables, but clearly longer than the short target-less vowel, and they usually retain full vowel quality.

- In the northern sub-dialects of the Northern dialect (e.g. Gaolth Dobhair), these vowels are short. Their duration is similar to that of the target-less vowel, and there is partial (or sometimes full) neutralisation as well as environment-dependent variation of vowel quality. In these sub-dialects, a sub-system of five short vowels evolved in unstressed syllables, four in the (almost) extreme peripheries, and one very centralised. The following chart demonstrates this system, and the allophonic variation is illustrated in the transcription of various lexical items21:

![Figure 3.2: The Sub-System of unstressed short vowels in the Northern Sub-Dialects of the Northern Dialect.](image)

The /e a/ contrast is maintained only between two ‘slender’ consonants, where /a/ is realised as low central [a] (e.g. *buidéal* ['bˠɪ.dˠæl] and *airnéál* ['ɛrˠ.ʃəl]). The vowel /e/ is

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21 The quadrilateral in the chart is similar in shape to the quadrilaterals used in most dialect descriptions. The placement of the vowels on the quadrilateral is according to the formant values (F1 plotted against F2) of these vowels in the utterances recorded with one representative speaker of the Gaolth Dobhair dialect. The top left angle roughly corresponds to the values {F1=250, F2=2200}, and the bottom right angle roughly corresponds to the values {F1=700, F2=850}.
given up elsewhere and merges with /a/, as demonstrated by the alternation in *buidéil/buidéal* [ˈbˠiːd̪eːl̪]/[ˈbˠiːd̪al̪ˠ].

Notice that, apart from the infrequent contrast just mentioned, and the contrast between the high-front variant of the neutral vowel (e.g. [i] in *dílis* [d̪iːl̪ˠiːf̪]) and the front variant of the high rounded vowel (e.g. [y] in *glinniúint* [ɟl̪ˠiːn̪ˠiːnt̪]), this vowel system is maximally dispersed. The /u/ vowel, with the [u u y] continuum, nevertheless remains auditorily distinct as a result of lip-rounding, a dimension whose independent application is probably not attested elsewhere in the language. However, following (O’Rahilly 1932:102), for many speakers of these dialects the /u œ/ contrast is neutralised in non-word-final position, and the [u œ i] continuum is applicable for both, e.g. *casúr/casúir/glinniúnt* [ˈk̪aː.s̪ər̪]/[ˈk̪aː.s̪ər̪ˠ]/[ɟl̪ˠiːn̪ˠiːnt̪] similar to *eolas/eolais/dílis* [ˈeːl̪ˠæs̪]/[ˈeːl̪ˠæʃ̪]/[d̪iːl̪ˠiːʃ̪].

As this system is rather impoverished and maximally dispersed in most environments (/i œ u a/ or even /i œ a/ for many speakers), its susceptibility to *blurring* is very limited. Only the infrequent [i ɪ y ø] contrast between two ‘slender’ consonants seems to be susceptible to *blurring*.

From English spelling norms of Irish names O’Rahilly (1932:105) infers that shortening of unstressed long vowels was fully established in the Northern dialect only by the 18th century, but he also mentions that such articulation was by that time

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22 Except for the [u: uː] contrast in stressed syllable in some Northern sub-dialects.

23 Ní Chiosáin (personal communication) recently found a few instances of glottalisation and devoicing of a second-syllable final nasal in connected speech recorded with a representative informant of the Gaoth-Dobhair dialect. I found substantial devoicing effects of a second-syllable final liquid in short phrase utterances recorded with the same informant. Such devoicing effects reduce the intensity of the final sonorant, and may help overcome a *blurring effect* of the sonorant following a quality-distinct unstressed short vowel, in a manner similar to the systematic alternations presented in section 3.3.3 below. As there is no systematic data on these devoicing processes in unstressed syllables, I shall not elaborate on this matter and leave it for future research.
‘long scorned as vulgarism’. As County Donegal is typically rural to this very day, with no cities and very few urban settlements, it is quite likely that ‘vulgar’ speech was the norm in Donegal, and that, in Donegal, the sub-system of unstressed short vowels was established a few generations earlier.

As for stressed syllables, although it is clear that they permit long vowels, many cases of optional shortening (i.e. free variation between long and short vowel) indicate long vowels are disfavoured there as well:

Systematic shortening is reported before [h] (Hughes 1994:625, Ó Baoill 1996:3), e.g. màthair [mʰaːhɔɾ] ‘mother’, (cf. [mʰаːhɔɾ] in the other dialects).

Sporadic shortening is attested for many lexical items (Ó Baoill 1996:3), e.g. móráin [mʰˌɾan̪ʲ] ‘many’, spúnóg [spʰˌnɔːɡ] ‘spoon’ ([mʰˌɾan̪ʲ], [spʰˌnɔːɡ] in other dialects).

Most interesting is the treatment of the stressed falling diphthongs /iə/ and /uə/, a treatment that seems to follow a sub-dialectal division similar to the division attested for unstressed long vowels: In the southern sub-dialects (e.g. Teilinn, Gleanncholmcille) falling diphthongs are tolerated and not shortened, whereas in the northern sub-dialects (e.g. Tory Island, Ros Goill, Gaoth Dobhair), there is a tendency to shorten falling diphthongs: the first part of the diphthong (where the accent falls in other dialects) becomes a glide or deletes completely, and the stress falls on the second part, whose quality seems be determined by the following consonant, e.g.: uachtar

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24 By that time the Northern dialect was spoken in many places in Ulster and was not confined to County Donegal.
25 Initial stress in the Western dialect, final stress in the Southern dialect.
26 Another process of labial dissimilation e.g. fuar ‘cold’ [fuːɾ] ([fuːɾ] in other dialects) is reported for these sub-dialects. However, as this process does not involve shortening it is irrelevant for the discussion.
27 This phenomenon is only rarely mentioned in dialect descriptions, e.g. Hamilton (1974), Ó Baoill (1996), and the environments in which shortening takes place, as well as the role of the following consonant in the specification of vowel quality is still to be clarified.
Given these tendencies it is rather safe to say that, although permitted, long vowels are disfavoured in the Northern dialect, especially in its northern sub-dialects.

3.2.3.2 Short Vowels

Unstressed short vowels In Irish lack a target quality and are merely a vocalic transition from the previous sound to the following one, commonly transcribed as [ə]. This convention is followed henceforth, but it should be kept in mind that the actual vowel quality is not at all necessarily schwa-like. As the unstressed short vowel has no contrastive quality, it is not subject to auditory blurring.

In stressed syllables, short vowels might have more than 20 vowel qualities (see e.g. Sommerfelt 1922), but most of these are allophonic realisations depending on the consonantal environment and the amount of phonetic secondary articulation of the adjacent consonants. A number of scholars (Ward 1974, Ó Siadhail 1989, Ní Chiosáin 1991) have managed to reduce the number of stressed short vowel phonemes to three, namely high, mid and low vowel, with horizontal tongue position and lip rounding derived according to the environment. The actual number of short vowel phonemes is not crucial, and the important point is that given a certain consonantal environment, a stressed short vowel can have up to three distinct qualities, e.g. [u/γ, θ/ʌ, θ/æ] between two ‘broad’ consonants, [u/i, θ/ʌ/3, θ/a] between a ‘broad’ consonant and a ‘slender’ consonant or between a ‘slender’ consonant and a ‘broad’ consonant, and [i, e, æ] between two ‘slender’ consonants...
According to McManus’ (1994:346-347) summary of the development of short vowels in Early Modern Irish, it may be safely inferred that the ternary-height distinction among short vowels had been established by the 13th century. According to the blurring effect hypothesis, given their shortness, their ternary-contrastive quality, and their diverse allophonic realisations, stressed short vowels are susceptible to blurring in Irish, and they are our main concern.

The IPA symbols used for transcribing short vowels henceforth are in accordance with the quality specifications mentioned in the dialect descriptions, rather than with the symbols used in these descriptions.

The symbols used below are: [i i u y u] (high vowels), [ɛ ɜ o ɔ] (mid vowels), [æ ə a ɑ ɒ] (low vowels).

3.2.3.3 Stress-Timing, Syllable-Timing and Vowel Duration

Most dialects of Irish seem to behave in a similar manner to most dialect of English with regard to the effect of stress on vowel duration: Unstressed short vowels are shortened and unstressed long-vowels tend to receive secondary stress. This was probably the case in Early Modern Irish as well. The Northern dialect, however, is an exception: Secondary stress is practically non-existent, vowel duration is less flexible and is not easily adjusted to meet stress frames. The quadri-syllabic word iriseoireacht ‘journalism’ can illustrate these dialectal tendencies: Southern [ˈɪɾɪ.ɾo.ˈʃo.ɾo.ɾɛxt], Western [ˈɪɾo.ʃo.ɾo.ɾɛxt], Northern [ˈɪɾo.ʃa.ɾajəɾɛxt].

According to Ní Chasaide (personal communication), this difference is a

28 Phonological theories that pursue the principles of ‘lexicon optimisation’ and ‘richness of the base’, like Optimality Theory (OT), categorically imply that if a sound present in the phonetic encoding of a lexical item never participates in alternations and always surfaces with the same quality, this quality must be present in the lexicon. As each dialect of Irish has at least a dozen of allophonic qualities for stressed short vowels, and as each such quality is fixed in all the derivatives of at least one lexical item, a strict OT analysis should ultimately recognise each such quality as underlying.
manicdation of a stress-timing system in the Southern and Western dialects, opposed to a tendency towards a syllable-timing system in the Northern dialect. Ni Chasaide asserts that this behaviour of the Northern dialect is tightly linked to the tendency to shorten unstressed as well as stressed long vowels, and claims that it is not clear which of the two developments, shortening of long vowels and syllable-timing, is responsible for which. The matter of stress-timing vs. syllable-timing is relevant for the susceptibility of short vowels to blurring in monosyllabic words containing a lax sonorant as simple coda:

- Due to the shortness of such a stressed rhyme, and the predominantly initial-stress nature of the language, the interval between this stress unit and the following stress unit is too short in a stress-timing system and the vowel is likely to be lengthened. This lengthening helps the short vowel to overcome blurring by the following sonorant.

- In a syllable-timing system, on the other hand, this is less likely to occur: as syllable duration depends predominantly on the number of segments in the syllable, vowel lengthening is unnecessary if there are enough consonants within the timing interval. A complex onset (in the monosyllabic word or in the first syllable of the following word, depending on whether the timing point is between consecutive onsets or consecutive rhymes, respectively) may easily compensate for a short rhyme, and therefore the vowel is not lengthened. As a result, its susceptibility to blurring remains high.

3.3 Vocalic Alternations in Contemporary Dialects

The following sections describe the phonological alternations in Irish, which involve circumstances where a stressed (quality distinct) short vowel is followed by a tautosyllabic fully voiced sonorant. Such environments are at least circumstantially related
to the *blurring effect* hypothesis in its finer details, and a phonological account of the
alternations presented might gain from taking the *blurring effect* hypothesis into
consideration.

### 3.3.1 Epenthesis

A phenomenon common to all the dialects is vowel epenthesis between a lax coronal
sonorant (l̃, l̂, ñ, n̂, r, r̂) and an immediately following non-coronal which is not a
voiceless stop (that is: b̃, b̂, m̃, m̂, f̃, f̂, v, v̂, g, j, x, ç, ɣ). This epenthesis occurs
after a short stressed vowel only (see e.g. Ó Siadhail 1989:20-22). Cross-dialectally
representative examples from the Western sub-dialect of Cois Fhairrge are:

\[(3.2)\]

\[
\begin{align*}
\text{dearg} & \quad \text{‘red’} & \quad [d̂æ.ɾ̄ɪ̄g] & \quad \text{deirge} & \quad \text{‘red comp.’} & \quad [d̂̄ɛ.ɾ̄o.ɪ̄ɾ̄] \\
\text{colm} & \quad \text{‘dove’} & \quad [k̂.l̂.ɪ̄o.m̂ɪ̄] & \quad \text{coilm} & \quad \text{‘doves’} & \quad [k̂̄ɔ.ɪ̄o.m̂ɪ̄] \\
\text{leanbh} & \quad \text{‘child’} & \quad [l̃.ɪ̄.ñ.ɔv] & \quad \text{linbh} & \quad \text{‘child gen.’} & \quad [l̃ɪ̄.ñ.ɔv] 
\end{align*}
\]

Notice, in the inflected forms above, that in the ‘broad/slender’ alternation (another
morphological and syntactic operation involving consonantal mutation, with final
consonants this time) there is a ‘broad/slender’ agreement between the final
consonants. Following Ní Chiosáin (1999), this is the only concrete cross-dialectal
evidence for the epenthetic nature of this vowel. Such agreement is not maintained
if the vowel between the two consonants is not epenthetic:

\[(3.3)\]

\[
\begin{align*}
\text{miolam} & \quad \text{‘defect’} & \quad [m̃h.ɪ̄o.m̂ɪ̄] & \quad \text{miolaim} & \quad \text{‘defects’} & \quad [m̂.ɪ̄o.m̂ɪ̄] \\
\text{drolamh} & \quad \text{‘loop’} & \quad [d̂̄ɾ̄.l̂.ɪ̄o.ɪ̄v] & \quad \text{drolaimh} & \quad \text{‘loops’} & \quad [d̂̄ɾ̄.l̂.ɪ̄o.ɪ̄v] 
\end{align*}
\]

Epenthesis is not applicable if the vowel is long, or if the second consonant is a

---

29 Optional absence of the epenthetic vowel, epenthesis in compounds across word boundaries, and
syllabification judgements are other – dialectal - types of evidence for the epenthetic nature of the
vowel.
voiceless stop:

(3.4)

dualgas  ‘duty’  [dʒuːlɡəs]
fáirbre  ‘notch’  [færbrə]
tháirg  ‘produced’  [hærɪɡ]
olc  ‘bad’  [ɔlk̜]
corp  ‘body’  [kɔrp̩]

There are, however, some cross-dialectal differences with regard to the application of the epenthesis: In the Southern dialect, epenthesis occurs also in compounds across word-boundaries (examples from Ó Cuív 1944:106)⁴⁰:

(3.5)

gearr ‘little’ [jar]  +  chuid ‘some’ [xud̪]  =  gearrchuid ‘fair amount’ [jarəxud̪]

baill ‘body organ’ [bˠal̩]  +  chrioth ‘trembling’ [cɾiθ]  =  bal̀lchrioth ‘trembling of the limbs’ [bˠal̩ɔɾiθ]

sean ‘old’ [ʃan̩]  +  bhean ‘woman’ [vən̩]  =  seanbhean ‘old woman’ [ʃan̩əvən]

an- ‘very-’ [an̩]  +  mhaith ‘good’ [vəh]  =  an-mhaith ‘very good’ [an̩əvəh]

The an- (‘very-‘) morpheme seems to involve epenthesis in the Western dialect as well, but other such prefixes do not, and the phenomenon is generally restricted to words only and does not affect compounds.

In the Northern dialect there is no epenthesis in the case of an-. Moreover, very recent recordings made by the author with one representative speaker of the Gaoth Dobhair dialect show sporadic lack of epenthesis as well as instances of free variation in words where epenthesis is expected. Examples are:

³⁰ The first consonant of the second word in each compound is lenited, the basic forms of these words are: cuid, crioth, bean, maith.
To the extent that the speech of one informant is representative, these examples are evidence both of a more restricted application of epenthesis in this sub-dialect as well as of the epenthetic nature of the vowel.

3.3.2 Vowel Lengthening Before Tense Sonorants and Consonantal Clusters

Following Ó Siadhail (1989:48-56), short vowels are lengthened in stressed syllables in certain circumstances. These circumstance are:

- preceding a tauto-syllabic (originally) tense sonorant (/(/(ë À Á Ë À Ê À Ì À Ï À ËÀ ËÀ)/).  
- preceding a coronal cluster comprising of a (lax) sonorant and a coronal other than /t/ (rs, rd, rn, rl, ls, ld, ln, lr, ns, nd, nl, nr)  
- preceding a cluster comprising of a voiced obstruent and a (lax) coronal sonorant (bl, br, vn, vl, vr, dr, gl, gr)

In phonology, the only true evidence for lengthening is short/long vowel alternations. As most descriptive literature of the Irish dialects is typically more committed to dialectology and diachronic developments rather than phonology and synchronic alternations, it is impossible to provide data showing length alternations for all these consonantal environments, and suffice it to say that many dialect descriptions provide 

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31 The informant, Eamon Ó Domhnaill, is the editor of ‘Beo’, an e-magazine in Irish. He has a high academic education in Irish, and has an acute awareness of both sub-dialectal variation and grammaticality. He defines himself as a representative speaker of Gaoth-Dobhair Irish. These sporadic deviations from the epenthesis norm could be his own idiolect, but are more likely representative of his sub-dialect.
Long Vowel

Representative alternations from the Western dialect are:

(3.7)

<table>
<thead>
<tr>
<th>Env.</th>
<th>Short Vowel</th>
<th>Long Vowel</th>
</tr>
</thead>
<tbody>
<tr>
<td>_ (R)</td>
<td>bearraim ‘I shave’ [ˈbaɪ.ɾaɪm]</td>
<td>bearrthá ‘shaved’ [ˈbaɪ.ɾaɪθ]</td>
</tr>
<tr>
<td>_ L³</td>
<td>geallaim ‘I promise’ [ˈgeɪ.ɫɭ.ɪm]</td>
<td>geallta ‘promised’ [ˈɡeɪ.ɫɭ.ɪθ]</td>
</tr>
<tr>
<td>_ L¹</td>
<td>millim ‘I destroy’ [ˈmɪ.ɫɭ.ɪm]</td>
<td>mille ‘destroyed’ [ˈmɪ.ɫɭ.ɪθ]</td>
</tr>
<tr>
<td>_ N³</td>
<td>clanna ‘clans’ [ˈklɭ.n.ɭ.ɪθ]</td>
<td>clann ‘children, clan’ [ˈklɭ.n.ɭ.ɪθ]</td>
</tr>
<tr>
<td>_ N¹</td>
<td>cinnim ‘I fix’ [ˈkɪ.ɲɭ.ɪm]</td>
<td>cinnte ‘fixed’ [ˈkɪ.ɲɭ.ɪθ]</td>
</tr>
<tr>
<td>_ m³</td>
<td>ama ‘time gen.’ [ˈa.ɭ.ɪm]</td>
<td>am ‘time nom.’ [ˈa.ɭ.ɪθ]</td>
</tr>
<tr>
<td>_ m¹</td>
<td>ime ‘butter gen.’ [ˈɪ.ɭ.ɪm]</td>
<td>im ‘butter nom.’ [ˈɪ.ɭ.ɪθ]</td>
</tr>
<tr>
<td>_ j</td>
<td>rangannai ‘classes’ [ˈraŋ.n.ɭ.ɪi]</td>
<td>rang ‘class’ [ˈraŋ]</td>
</tr>
<tr>
<td>_ n</td>
<td>ionga ‘nail’ [ˈi.ɲ.ɭa]</td>
<td>ingne ‘nails’ [ˈi.ɲ.ɭa]</td>
</tr>
<tr>
<td>_ r²</td>
<td>doras ‘door’ [ˈdə.ɭ.ɪɹ]</td>
<td>(doirse ‘doors’ [ˈdə.ɭ.ɪɹ.ɭa])</td>
</tr>
<tr>
<td>_ rd</td>
<td>cara ‘friend’ [ˈkə.ɹa]</td>
<td>cairde ‘friends’ [ˈkɭ.aɹ.ɭa]</td>
</tr>
<tr>
<td>_ r²</td>
<td>foréann ‘team’ [ˈfə.ɭ.ɪɹ.ɭa]</td>
<td>fóirne ‘teams’ [ˈfə.ɭ.ɪɹ.ɭa]</td>
</tr>
<tr>
<td>_ ls</td>
<td>solas ‘light’ [ˈsə.ɭaɹ]</td>
<td>soilse ‘lights’ [ˈsə.ɭaɹ]</td>
</tr>
<tr>
<td>_ ns</td>
<td>inis ‘Tell!’ [ˈi.ɲ.ɭi]</td>
<td>inseachta ‘telling’ [ˈɪ.ɲ.ɭi.ɹət]</td>
</tr>
<tr>
<td>_ br</td>
<td>obair ‘work nom.’ [ˈə.ɹ.əɹ]</td>
<td>oibre ‘work gen.’ [ˈə.ɹ.əɹ]</td>
</tr>
<tr>
<td>_ bl</td>
<td>pobal ‘public’ [ˈpə.ɹ.əɹ]</td>
<td>poiblí ‘public (adj.)’ [ˈpə.ɹ.əɹ.ɹiː]</td>
</tr>
<tr>
<td>_ vr</td>
<td>soibhíbh ‘rich’ [ˈsə.ɹ.ɭ.ɪɹ]</td>
<td>soibhreas ‘richness’ [ˈsə.ɹ.ɭ.ɪɹ.ɹ]</td>
</tr>
<tr>
<td>_ dr</td>
<td>paidir ‘prayer’ [ˈpə.ɹ.ɹɪ.ɹ]</td>
<td>paidrín ‘rosary’ [ˈpə.ɹ.ɹɪ.ɹɪː]</td>
</tr>
<tr>
<td>_ gr</td>
<td>freagairt ‘answering’ [ˈfrə.ɹə.ɹəɹ]</td>
<td>freagra ‘answer’ [ˈfrə.ɹə.ɹəɹ]</td>
</tr>
</tbody>
</table>

In the Southern dialect, similar alternations take place. However, there are two major differences:

- As mentioned earlier, the lax/tense contrast for coronal sonorants is lost in the Southern dialect. On the surface, lengthening alternations takes place in certain lexical items but not in others: millim [ˈmɪ.ɫɭ.ɪm], mille [ˈmɪ.ɫɭ.ɪθ]


32 As mentioned earlier, the preservation of ‘broad’ lax/tense contrast in the Western dialect is rare, and is explicitly mentioned only for a minority of speakers within the Cois Fhairrge dialect (de Bhaldráithe (1945:41)). These alternations are supposedly representative of their speech.

33 Vowel lengthening before an /rs/ cluster is rare in the Western dialect, and doirse is actually pronounced [ˈdə.ɭ.ɪɹ.ɭa]. The form with the lengthened vowel given is from the Southern dialect.

- Clusters comprising a voiced obstruent followed by a sonorant are avoided, and such environment for lengthening is absent altogether: oibre [ˈibə.rə], paidrín [pə'ə.də.ɾi:n], freagra [fɾə'ə.ɾə] (see Ó Siadhail 1989:55).

In the Northern dialect, including the sub-dialects of County Mayo, vowel length alternations are only sporadic, and typically involve specific lexical items containing /rC/ clusters or original /ɾ/, such as: cara [ˈkə.rə] ‘friend’, cairde [ˈkə:r.də] ‘friends’; aird [ə:r'də] ‘height’, ard [ər'də] ‘high’; barra [bə'ə.rə] ‘crops’, barr [bə'ə:r] ‘crop’.

In all other cases, length alternations are absent in the Northern dialect, and short vowels are maintained throughout. In the examples mentioned above: geallta [ˈɡəltə], millte [ˈmltl.tə], clann [klɒ'ən], cinnte [ˈcəntə.tə], am [əm], im [im], rang [rəŋ], ingne [ˈŋ.nə], doirse [ˈdərsə], foirne [ˈfəɾnə], soilse [ˈsələ], insint [ˈıəntə], oibre [ˈeibəɾə], paidrín [pə'ədəɾin] etc.

Needless to say, lexical long-vowels do not involve similar length alternations, and they are pronounced long in all environments in all dialects:

(3.8)

céime ‘degree gen.’ [ˈcɛim] céim ‘degree nom.’ [cəm]
cúngach ‘narrow space’ [kʊŋəx] cúng ‘narrow’ [kʊŋ]
geillim ‘I yield’ [ˈje.əm] géill ‘Yield!’ [je'əl]

Short vowels are not lengthened in other environments, i.e. before a tauto-syllabic lax sonorant or obstruent (except for the clusters mentioned above), and are always

34 [je:ɻ(əm)] in the Southern dialect.
permitted before a coronal cluster involving a lax sonorant + /t/ (again representative
forms from the Western dialect of Cois Fhairrge):

(3.9)

<table>
<thead>
<tr>
<th>Irish word</th>
<th>North</th>
<th>West</th>
<th>South</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>rudai</em> ‘things’</td>
<td>[ˈru.dˠiː]</td>
<td>[ˈru.dˠiː]</td>
<td>[ˈru.dˠiː]</td>
</tr>
<tr>
<td><em>peile</em> ‘football gen.’</td>
<td>[ˈpˠe.l̠ˠə]</td>
<td>[ˈpˠe.l̠ˠə]</td>
<td>[ˈpˠe.l̠ˠə]</td>
</tr>
<tr>
<td><em>molaim</em> ‘I praise’</td>
<td>[ˈmˠə.l̠ˠəmˠ]</td>
<td>[ˈmˠə.l̠ˠəmˠ]</td>
<td>[ˈmˠə.l̠ˠət̠ˠə]</td>
</tr>
<tr>
<td><em>canaim</em> ‘I sing’</td>
<td>[ˈkˠə.nˠəmˠ]</td>
<td>[ˈkˠə.nˠəmˠ]</td>
<td>[ˈkˠə.nˠəl̠ˠə]</td>
</tr>
</tbody>
</table>

Also: *port* ‘jig’ [pˠɔrtʃ], *scairt* ‘shout’ [sk̡aɾt], *folt* ‘hair’ [fˠɔltʃ], *Ceilt* ‘Celt’ [ˈkəl̠ˠt],
*punt* ‘pound’ [pˠɔntʃ] etc.

Finally, a short vowel in an unstressed syllable is not lengthened in any dialect

(3.10)

Notice also that in all these forms in the Southern dialect, stress remains on the
first syllable, that is, the second syllable is not regarded as heavy. This is not
always true with final /rd/, at least in certain compounds and old borrowings,
where the original contains a short vowel: *iomard* (*iom-ard*) ‘illness’ [ˈi.ɾˠərdʃ],
*Risteard* ‘Richard’ [ɾˠi.ɾˠərdʃ], *bligeard* ‘black-guard’ [bˠli.ɾˠərdʃ]35.

Vowel lengthening before obstruent-initial clusters such as /vr br bl gr dr/ is not
discussed further in this thesis, except for certain comments in section 4.2.1 below.

35 Notice that at the time of the borrowing this vowel may probably have been [a] rather than [ə] as in
contemporary English dialects.
3.3.3 Devoicing of Final Lax Sonorants after Stressed Short Vowels

Following Ní Chasaide (1979: 68-70), Ó Siadhail (1989: 90) and Hughes (1994: 623), in a monosyllabic word containing a short vowel followed by a lax coronal sonorant as coda, this sonorant is devoiced in the Northern dialect. Devoicing is achieved by aspiration and/or glottalisation, and the sonorant is typically accompanied by a slight fricative noise. Here are a few examples of the relevant alternations:

(3.11)

<table>
<thead>
<tr>
<th>Fully voiced lax sonorant in:</th>
<th>Alternates with devoiced in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>dearaim [dʒa.ɾəm̩] ‘I design’</td>
<td>dear [dʒar][dʒar] ‘Design!’</td>
</tr>
<tr>
<td>molaim [mɬ.ɾəm̩] ‘I praise’</td>
<td>mol [mɬa][mɬa] ‘Praise!’</td>
</tr>
<tr>
<td>silim [ʃi.ɾəm̩] ‘I drop’</td>
<td>sil [ʃi][ʃi] ‘Drop!’</td>
</tr>
<tr>
<td>canaim [kə.ɾəm̩] ‘I sing’</td>
<td>can [kəa][kəa] ‘Sing!’</td>
</tr>
<tr>
<td>cluinim [kl̥i.ɾəm̩] ‘I hear’</td>
<td>cluin [kl̥i][kl̥i] ‘Hear!’</td>
</tr>
</tbody>
</table>

If the vowel is long, or if the sonorant is non-lax, there is no devoicing:

(3.12)

| mór ‘big’ [məɾ] | beoir ‘beer’ [bɹr] |
| béal ‘mouth’ [bɹl] | sil ‘Think!’ [ʃi:l] |
| dán ‘poem’ [dǎn] | ruin ‘secrets’ [ruːn] |
| poll ‘hole’ [pəɾ] | cill ‘church’ [ʃiɾ] |
| leann ‘ale’ [ləɾ] | sinn ‘we’ [ʃiɾ] |
| am ‘time’ [əɾ] | im ‘butter’ [ɪɾ] |
| long ‘ship’ [ləɾ] | moing ‘thickness’ [mɹɾ] |

According to Ní Chasaide (1999:114), short vowels preceding devoiced sonorant are over-short. However, Ní Chasaide (personal communication) says that this over-shortness is in comparison with vowels before tense sonorants. It is not clear therefore whether short vowels are extra-short before lax sonorants, or half-long before tense sonorant, in this dialect.
3.4 Summary

This chapter surveyed the phonological system of Irish highlighting the characteristics which, it will be seen, are relevant to the *blurring effect* hypothesis. It also presented certain phonological alternations that typically involve an underlying form containing a sequence of a stressed (quality distinct) short vowel followed by a tauto-syllabic sonorant.

These alternations are at least circumstantially related to the *blurring effect* hypothesis, with its finer details, and might indeed result from the incorporation of the *blurring effect* and its implications into the grammar and from the interaction between the *blurring effect*, possible grammatical repair mechanisms and other other grammatical tendencies of the dialects of Irish. As such, incorporating the *blurring effect* into the theoretical account to these alternations may improve the explanatory adequacy of such an account. The following chapter presents an account to these alternations in a manner that places the *blurring effect* in the centre of the phonological system.
4 Theoretical Account

This chapter presents a theoretical account of the alternations described in chapter 3. The account suggests that these alternations are directly related to the blurring effect hypothesis, in the sense that they involve repair mechanisms that help overcome the blurring effect. The account is historical-phonological, in the sense that it explains the diachronic development of the various alternations in the various dialects, taking into account both the blurring effect hypothesis and other dialectal factors that interact with it.

The account is rather informal, but it is based almost entirely on constraint interaction, and as such it can be transformed into a formal Optimality-Theoretic account. As auditory phonology plays a central role in this account, and as the evaluation of auditory constraints should involve both probabilistic considerations (e.g. ‘what are the chances that the vowel is auditorily blurred in form X?’) as well as continuous, rather than discrete, considerations (e.g. ‘what is the minimal vowel duration needed so that the vowel not be susceptible to blurring in this particular environment?’), a formal presentation of the account was considered too intricate to undertake within the context of this thesis.

This chapter begins by exploring the notion that the epenthesis and lengthening alternations are conspiratory. It continues with an account of another alternation in Early Modern Irish which seems to constitute the common origin of both epenthesis and lengthening. An account of the development of epenthesis and lengthening is proposed, along with the development of their manifestations in the various dialects. Within the descriptions of the developments in the Northern dialect, an account is proposed of the sonorant (de)voicing alternations. Finally, a number of earlier theoretical accounts for these alternations are surveyed.
4.1 Vowel Epenthesis and Vowel Lengthening as conspiratory

In order to account for these alternations in Irish, I propose that they all involve, or more accurately, historically involved, repair mechanisms that help overcome the blurring effect. As will become clear immediately, the vowel epenthesis and vowel-length alternations are historically related to one another and phonologically conspiratory, that is, they are different mechanisms applied to serve the same purpose. An adequate account should therefore account for both. First I would like to demonstrate the conspiratory nature of both mechanisms in detail, and then move on to explain the rationale behind my proposal.

4.1.1 Distributional Evidence

When a stressed vowel is followed by a sonorant in coda position, neither epenthesis nor lengthening take place if (a) the vowel is long, or if (b) the sonorant is lax and word-final, or (c) the sonorant is lax and is followed by a voiceless stop. This negative evidence is unlikely to be coincidental.

The positive evidence, however, is even stronger, because it covers all other environments, in which epenthesis and lengthening are applied in complementary distribution: If the coda sonorant is followed by a homorganic consonant or if the sonorant is tense and word-final, vowel lengthening takes place. If the sonorant is followed by a heterorganic consonant, epenthesis takes place.

This complementary distribution did not escape Ó Baoill (1980) and Ní Chiosáin (1991), whose unified accounts for the same phenomena are discussed later.

4.1.2 Cross-Dialectal Mechanism Variation

There are consonantal environments which involve epenthesis in one dialect but lengthening in another. If complementary distribution of the two mechanisms across phonological environments is evidence of their conspiratory nature, than cross-
dialectal variation vis-à-vis their application in the same phonological environment is even stronger evidence. Following are a few such cases:

- **[rn] cluster**: Inter-vocally this cluster always involves lengthening in the Western and Southern dialect. E.g. *foireann* [fɔɪɾən] ‘team’ *foirne* [fɔɪɾən] ‘teams’. Following O’Rahilly (1932:50,200) and Ua Súilleabháin (1994:484), however, word-finally a [rn]-cluster is broken by epenthesis after a short vowel in these two dialects, but remains intact in the Northern dialect (and in Scottish Gaelic), with optional lengthening of the preceding short vowel. Thus, for example, *carn* ‘heap’ and *dorn* ‘fist’ are [kɑɾən], [dəɾən] in the Western and Southern dialects, but [kɑɾ(ː)ɾən], [dəɾ(ː)ɾən] in the Northern dialect (and Scottish Gaelic).

- **[ms] and [lr] clusters**: O’Rahilly (1932:201) mentions that the clusters [ms], [lr], which do not involve alternations in the Northern Dialect, are susceptible to epenthesis in Scottish Gaelic, whereas lengthening is the norm in the Western and Southern dialect:

\[
\begin{array}{|c|c|c|c|c|}
\hline
\text{word} & \text{Northern} & \text{Western} & \text{Southern} & \text{Scottish} \\
\hline
\hline
\end{array}
\]

- **Idiosyncratic lexical items**: Certain lexical items show this kind of distribution with other clusters. Ó Curnáin (2002) discusses, for example, the pronunciation of the word *dearmad* ‘mistake’ in various dialects, using data from the Linguistic Atlas and Survey of Irish Dialects (Wagner 1958:163). Certain Northern and Western sub-dialects retain a short vowel and an intact cluster, i.e. [dɛɾ.ɣam.ɾəɾ], other Northern and Western sub-dialects have epenthesis, i.e. [də.ɾa.m.ɾəɾ], while certain other Western sub-dialects have
lengthening and the cluster remains intact, i.e. [drər.məd̪ˠəd̪ˠ]36.

4.1.3 Simultaneous Historical Emergence in Poetry and English Spelling
According to O’Rahilly (1932:51-52, 201-202), evidence of both lengthening and epenthesis in English spelling of Irish names emerges at precisely the same time, that is the second half of the 16th century, e.g. Balefoyle (Irish: Baile an Phuill), Downeboillig (Irish: dún Bolg). It stands to reason that once a phonological change is established in language A, it would appear in spelling of borrowings from language A into language B, as the spelling in language B is not subject to language A conventions and follows only the sound-to-symbol conventions of language B. Conservative orthographic conventions in language A, on the other hand, would delay its emergence in spelling in language A for some time. Not surprisingly, from spelling in Irish texts as well as from rhyming conventions in Irish poetry, evidence for both lengthening and epenthesis is attested a bit later, that is, from the early 17th century and onwards (see Williams 1994:448 for lengthening and McManus 1994:355 for epenthesis). The simultaneous emergence of evidence of both epenthesis and lengthening in spelling is very unlikely to be coincidental, and enables us not only to state that they emerged more or less simultaneously, but also to date their stabilisation to the mid 16th century.

4.1.4 Common Historical Origin: Vowels of Intermediate Length
The last and most convincing piece of evidence for the conspiratory nature of epenthesis and lengthening is simply the fact that they developed from the same historical source, namely closed syllables containing a vowel whose length is intermediate between short and long, in Early Modern Irish.

36 In most S sub-dialects the word is pronounced [də.ru:d̪ˠ].
According to Greene (1952), O’Rahilly (1932:51), and McManus (1994:344), the 16th century manuscripts of the Irish schools of bardic poetry, which are the main source of information on Early Modern Irish, recognised three distinct vowel quantities in stressed syllables:

- **Short vowels** (*sineadh gearr*), corresponding to short vowels in contemporary dialects.

- **Long vowels** (*sineadh fada*), corresponding to most long vowels in contemporary dialects.

- **Intermediate vowels** (*sineadh meadhónach*).

Intermediate was the length of originally short vowels, in the following environments and in these environments exclusively (consonants may be ‘broad’ or ‘slender’):

- Before word-final or pre-consonantal tense sonorants: _ {R L N M Ы} {# C}.

- Before clusters comprising of a lax sonorant or voiced fricative or glide, followed by a voiced stop, a voiceless fricative, a lax or tense sonorant, a voiced fricative or a glide, that is: _ {R N L W/V Ы/Ь} {B D G F S X R L N M Ы W/V Ы/Ь}.

In unstressed syllables, only short and long vowels were recognised, and a short vowel always had neutral, or non-distinctive quality, whereas long vowels retained distinct vowel qualities (McManus1994:344-345).

Notice that pre-sonorant short vowels were retained only if the sonorant was intervocalic or if it was a lax-sonorant followed by nothing (word finally) or by a voiceless stop (p t k). In all other cases, stressed pre-sonorant vowels of originally short quantity were lengthened to intermediate. As McManus(1994:344) further mentions (and as must be apparent to the reader by now, all environments containing an intermediate vowel in Early Modern Irish, gave rise either to long vowels / diphthongs or to epenthesis in contemporary dialects.
4.1.5 Epenthesis and Lengthening as Conspiratory – Summary
There is plenty of evidence, both from phonological distribution, cross-dialectal variation in application, and simultaneous historical emergence, for the conspiratory nature of vowel epenthesis and vowel lengthening. The strongest piece of evidence, however, is probably the fact that both vowel epenthesis and vowel lengthening are modern reflections of the same phenomenon in Early Modern Irish, namely the emergence of intermediate vowel length from lengthening of short vowels. An explanatorily-adequate account of the epenthesis and lengthening alternations should therefore not only capture the alternations themselves, but also account for their developments from the common source. It should ideally also account for the development of that common source, that is, the intermediate vowel length in Early Modern Irish. It therefore seems that the best place to start the account is with the emergence of the intermediate vowel length in Early Modern Irish.

4.2 Intermediate Vowel Length and the Blurring Effect

4.2.1 The Account
Following are the facts and assumptions mentioned earlier about Early Modern Irish:

- Consonants have phonetic secondary articulation. As a result, they are immune to co-articulatory effects of following vowels, and their auditory signal carries no information on the quality of a following vowel (see section 3.2.1.2 and references therein).
- Short vowels are quality distinct, probably according to a ternary vowel-height parameter, in stressed syllables only (see 3.2.3.2).
- Coronal sonorants involve a lax vs. tense contrast, which is manifested in short vs. long duration contrast. These relative durations are intrinsic to the articulatory gestures involved. The intrinsic duration hierarchy for sonorants
is, from longest to shortest (see 3.2.1.3.3):

Tense coronal sonorants > Non-coronal nasals > Lax coronal sonorants

- Voiceless stops are pre-aspirated. As a result a voiceless stop devoices the final portion of a preceding sonorant, and this devoicing effect involves a substantial decline in the intensity of the sonorant. The devoiced portion is supposedly of equal length across the various sonorants, but is relatively more effective in converse relation to the intrinsic duration of the various sonorants (see 3.2.1.4).

Following are the details of the *Blurring Effect* hypothesis:

- A postvocalic sonorant exerts an auditory *blurring effect* over a preceding consonant as a cumulative result of regressive co-articulatory colouring and backward masking (see 2.4).
- Backward masking increases the greater the duration and intensity of the masker (see 2.3.2.2.2).
- Backward masking decreases the longer the target (see 2.3.2.4).
- Both regressive co-articulatory colouring and backward masking are more effective tauto-syllabically than hetero- or ambi-syllabically (see 2.3.3).
- *Blurring* is ineffective when vowel quality is non-contrastive (see 2.3.2.4).

In light of all the information on Early Modern Irish and the *blurring effect* hypothesis, I propose that in Early Modern Irish, a stressed (quality distinct) short vowel was subject to a critical *blurring effect* by a following sonorant (or glide), unless the sonorant was substantially devoiced or was not tauto-syllabic with the vowel.

I further propose that lengthening of a short vowel to an intermediate length was applied as a repair mechanism in order to overcome this *blurring effect*.

Notice that as all the details of the *blurring effect* hypothesis are applicable for glides just as they are for sonorants, this proposal captures the lengthening of short vowels before
both sonorants and the glides [w] and [j]. As for the fricatives [v] and [ɣ], I suggest that they involved lengthening as a result of ‘broad’/’slender’ symmetry of the behaviour of their correlates, which are the glides [w] and [j] respectively. I also suggest that the similar patterning of /v/-initial-clusters to sonorant-initial clusters in the contemporary dialects stems from this common development of intermediate vowels. However, intermediate length is not found before stop-initial clusters, and this is captured by the current account which assumes that stops do not exert a blurring effect.

4.2.2 Informal Application Algorithm

The following chart presents an informal algorithm for the application of the lengthening of a short vowel to intermediate in Early Modern Irish, illustrated with representative lexical items:

<table>
<thead>
<tr>
<th>Lexical Item</th>
<th>Underlying Form</th>
<th>Critical Blurring Effect?</th>
<th>Lengthen?</th>
<th>Surface Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>léargas ‘insight’</td>
<td>/ləəˈrəɡæs/</td>
<td>No (long vowel)</td>
<td>No</td>
<td>[ləːˈrəɡæs]</td>
</tr>
<tr>
<td>dearg ‘red’</td>
<td>/dəːr̃/</td>
<td>Yes (by a fully voiced tauto-syllabic lax sonorant)</td>
<td>Yes</td>
<td>[dəːr̃]</td>
</tr>
<tr>
<td>dearc ‘Look!’</td>
<td>/dəːrk/</td>
<td>No (sonorant is devoiced by a voiceless stop)</td>
<td>No</td>
<td>[dəːrk]</td>
</tr>
<tr>
<td>céim ‘step’</td>
<td>/ceəml/</td>
<td>No (long vowel)</td>
<td>No</td>
<td>[ceəml]</td>
</tr>
<tr>
<td>teampall ‘temple’</td>
<td>/teəmpɔl/</td>
<td>Yes (the labial sonorant is intrinsically non-short, therefore its devoicing is limited)</td>
<td>Yes</td>
<td>[teəmpɔl]</td>
</tr>
<tr>
<td>geall ‘Promise!’</td>
<td>/ɡəlɔl/</td>
<td>Yes (by a tauto-syllabic tense sonorant)</td>
<td>Yes</td>
<td>[ɡəlɔl]</td>
</tr>
<tr>
<td>geallta ‘promised’</td>
<td>/ɡəlɔltə/</td>
<td>Yes (the sonorant is intrinsically long, therefore its devoicing is negligible)</td>
<td>Yes</td>
<td>[ɡəlɔl,tə]</td>
</tr>
<tr>
<td>gealltain ‘I promise’</td>
<td>/ɡəlɔltəɪl/</td>
<td>No (the sonorant is not tauto-syllabic)</td>
<td>No</td>
<td>[ɡəlɔl,təɪl]</td>
</tr>
<tr>
<td>capall ‘horse’</td>
<td>/kəpɔl/</td>
<td>No (the quality of the vowel in question is non-contrastive)</td>
<td>No</td>
<td>[kəpɔl]</td>
</tr>
<tr>
<td>geal ‘clear’</td>
<td>/ɡəl/</td>
<td>??? (see below)</td>
<td>???</td>
<td>???</td>
</tr>
</tbody>
</table>

With regard to geal (the last item in this chart), and all monosyllabic words

37 The syllable boundary is probably during the tense sonorant. I therefore refrain from marking it.
containing a short vowel and a lax sonorant as simple coda, I propose that, in most environments, the stress-timing mechanism (see section 3.2.3.3) automatically took care of the situation by slightly lengthening the vowel, to overcome the over-short duration of the syllable.

4.3 From Intermediate Vowel Length to Epenthesis or Further Lengthening

4.3.1 The Account

According to the proposal just presented, the emerging system of Early Modern Irish managed to cope with the blurring effect by lengthening short vowels to intermediate in critically blurring environments. The result, however, was a system involving a ternary quantity contrast, which, once grammaticised, is highly marked.

Whether the contrast between short and intermediate vowels, and, consequently, the ternary quantity contrast, was actually grammaticised or remained allophonic is immaterial\(^{38}\). The important point is that, once this contrast was established, it was likely to be dispensed with.

In order to avoid both the ternary quantity contrast and the blurring effect, there are two options that successfully dispense with the intermediate vowels:

- Retention of the short quantity of the vowel, achieved by splitting the short vowel and the blurring sonorant across syllable domains by vowel epenthesis after the sonorant.
- Further lengthening of the vowel to make it a truly long vowel.

Both option are possible, but both could theoretically give rise to homophones on a large scale. However, it so happens that, given the characteristics of the Irish lexicon,

\(^{38}\) Notice that, on one hand, it is very unlikely that the child acquiring the language and subconsciously recognising the complementary distribution of short and intermediate vowels would actually grammaticise the length contrast. On the other hand, it is likewise unlikely that the Bardic schools of poetry would define three distinct vowel quantities unless this ternary contrast was cognitively present.
neither of the mechanisms would actually yield large-scale homophony, apart from word final epenthesis (after a word-final tense sonorant). Still, it is clear that retention of the short quantity entails also full faithfulness to the vowel quality, whereas further lengthening involves the risk of quality merger with one of the intrinsically long vowel qualities. Even if such merger typically does not involve actual emergence of homophones, it should be disfavoured.

I therefore propose that, except for the case of word-final tense sonorants, the default mechanism to dispense with the intermediate vowels was the **retention of short quantity** accompanied by **post-sonorant vowel epenthesis**.

However, epenthesis might be problematic in a different way: If epenthesis were to separate two consonants which share the same articulators, the articulatory cost of the epenthesis would be very high: instead of staying in the same position, with only marginal adjustment, the active articulator would have to be released from the passive articulator (in order to introduce the vowel) and then placed in the same position again. It is therefore unlikely that epenthesis would operate between **homorganic** consonants.

Thus, although the retention of the short quality with post-sonorant epenthesis was the default option, it was inapplicable in two environments:

- word finally after a tense sonorant, due to the high risk of homophones.
- between homorganic consonants.

In these two environments, it is predicted that the intermediate vowels would be **further lengthened** to long vowels.

It is precisely at this point, where both vowel epenthesis and further vowel lengthening take place in complementary distribution, that both mechanisms become **conspiratory**.

### 4.3.2 Informal Application Algorithm

The following chart presents an informal algorithm for the complementary operation...
of vowel epenthesis and further vowel lengthening, illustrated with those lexical items that, by now, had an intermediate vowel underlyingly:

Table 4.2: Algorithm for the emergence of epenthesis and fully lengthened vowels.

<table>
<thead>
<tr>
<th>Lexical Item</th>
<th>Underlying Form</th>
<th>Problem for Epenthesis?</th>
<th>Shorten and Epenthesise?</th>
<th>Further Lengthen?</th>
<th>Surface Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>dearg ‘red’</td>
<td>/dearg/</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>[da.r̂ǎg]</td>
</tr>
<tr>
<td>teampall ‘temple’</td>
<td>/teampall/</td>
<td>Yes (homorganic cluster)</td>
<td>No</td>
<td>Yes</td>
<td>[t̂a.m̂p̂ôl̂]</td>
</tr>
<tr>
<td>geall ‘Promise!’</td>
<td>/geall/</td>
<td>Yes (risk of homophones)</td>
<td>No</td>
<td>Yes</td>
<td>[ga.l̂]</td>
</tr>
<tr>
<td>geallta ‘promised’</td>
<td>/geallta/</td>
<td>Yes (homorganic cluster)</td>
<td>No</td>
<td>Yes</td>
<td>[ga.l̂t̂a]</td>
</tr>
</tbody>
</table>

It should be noted that, at this stage, some variation emerged across dialects: some dialects did permit breaking of certain homorganic consonantal clusters, e.g. word-final [rn] clusters in the Western and Southern dialect, and [Ir] in Scottish Gaelic. It is beyond the remit of this account to explain why specific clusters in certain dialects deviated from the general norm.

4.3.3 Further Vowel Lengthening or Diphthongisation

Historically, further lengthening was blocked in the Northern dialect, and this section is relevant only for the other dialects. For further developments in the Northern dialect, including possible retention of the intermediate vowels to this very day, see 4.4.4.3 below.

In those environments where an intermediate vowel was further lengthened to a fully-long vowel, there were two options for the source of the additional vocalic material, as demonstrated by Ó Baoill (1979), Cyran (1997):

- The vowel itself, i.e. lengthening the vowel to make it a long monophthong, i.e. [V:].

---

39 ‘ ‘ marks additional vocalic material. For the added vocalic material see the next section.
40 These two sources refer to further lengthening or diphthongisation as processes affecting short, rather than intermediate, vowels.
• The vocalic on-glide of the following consonant (which involves secondary articulation), i.e. lengthening the on-glide to a full glide and the formation of a diphthong, i.e. [Vw] or [Vj].

Examples of such reconstructed realisations are:\[41:\]

Table 4.3: Full lengthening to long monophthongs or diphthongs.

<table>
<thead>
<tr>
<th>Lexical Item</th>
<th>Underlying Form</th>
<th>Lengthen to a monophthong</th>
<th>Lengthen to a diphthong</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>cam</em> ‘crooked’</td>
<td>/kæm^%/</td>
<td>[kæm^%]</td>
<td>[kæ%m^%]</td>
</tr>
<tr>
<td><em>aimsir</em> ‘weather’</td>
<td>/a%m^%or%/</td>
<td>[a%m^%or%]</td>
<td>[a%j%m^%or%]</td>
</tr>
<tr>
<td><em>lom</em> ‘bare’</td>
<td>/l%m^%/</td>
<td>[l%m^%]</td>
<td>[l%%m^%]</td>
</tr>
<tr>
<td><em>greim</em> ‘bite’</td>
<td>/pr%m%/</td>
<td>[pr%m%]</td>
<td>[pr%e%j%m%]</td>
</tr>
<tr>
<td><em>im</em> ‘butter’</td>
<td>/%m%/</td>
<td>[%m%]</td>
<td>[%j%m%]</td>
</tr>
<tr>
<td><em>tum</em> ‘Dip!’</td>
<td>/t%m%/</td>
<td>[t%m%]</td>
<td>[t%%w%m%]</td>
</tr>
</tbody>
</table>

However, the vocalic system already had the long vowels [i: e: o: u: ai au iω uω], and some mergers between the original long vowels and the new long vowels were inevitable. The new long high vowels, both in the monophthong form [i: u:] and the diphthong form [i:j u:w], were very likely to merge with the original long vowels [i: u:]. Indeed this happened in almost all dialects where full-lengthening took place:\[42:\] The new long mid vowels, in their monophthong forms [ɛ: ɔ: ɔː], are likely to merge with the original long vowels [ɛ: ɔ:]\[43:\]. In their diphthong forms, e.g. [ɛ:j ɔ:w], they might have survived, but as diphthongs are universally unstable, they might undergo various changes. The new long low vowels in their monophthong forms [æ: a: ə: ɜ:] were

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\[41:\] In the next few sections examples of lengthening always involve postvocalic [m]. Examples of lengthening before coronal sonorants is postponed pending discussion of the particular dialectal developments vis-à-vis the lax/tense contrast.

\[42:\] In the Southern dialect of Ring, however, [rj] did develop into a diphthong, e.g. *cill* ‘church’ [c\%ll] (Breatnach 1947:23. He transcribes the word with the diphthong [ai], but from his own description of the articulatory gesture it is clear that the diphthong is actually [e:i])

\[43:\] In most dialect descriptions, the short mid vowel [ɛ] is ‘perfect mid’, that is, between lower-mid and higher mid.
likely to merge with the original long vowel [aː]. In their diphthong forms, e.g. [aːj ãːw], they would inevitably merge with the original diphthongs [ai õu].

The modern Western and Southern dialects seem to reflect this variety of lengthening mechanisms for non-high vowels. For example, the low vowel in geall ‘Promise!’, cam ‘crooked’, and aimsir ‘weather’ lengthened to a long monophthong [æː] in the Western dialect of Cois Fhairrge, i.e. [jæːl̥, kæːm̥, æːm̥ʃoːɾ] (De Bhaldraithe 1945), and to a diphthong [ãu/ai] in the Southern dialect of West Muskerry, i.e. [jœːl̥, kœːm̥, əim̥ʃoːɾ] (Ó Cuív 1944). On the other hand, the mid vowel in bord ‘table’ developed eventually into the diphthong [au] in Cois Fhairrge, i.e. [bɔːrd̥]44, whereas it became a long monophthong in West Muskerry, i.e. [bɔːrd̥]. Generally speaking, diphthongisation seems to have been more robust in the Southern dialect than in the Western dialect.

4.4 Later Dialectal Developments

In the previous section I reconstructed certain surface forms that supposedly existed in Irish a few centuries ago (probably in the mid 16th century), when both further lengthening and epenthesis stabilised. However, without linking these reconstructed forms to the forms in the contemporary dialects, which are the (real) data that invoked the account in the first place, these reconstructed forms, as well as the whole account, would be in vain. In particular, certain contemporary forms that are unfaithful to the quality of the original half-long vowel, or unfaithful to the lax/tense contrast among coronal sonorants, have to be explained.

44 That merger of diphthongs took place and both [ou] and [au] became [au] in Cois Fhairrge is not surprising, given the instability of diphthongs. In fact, Ó Cuív (1944:30) reports precisely this merger for the younger generation of speakers in West Muskerry, which is the dialect that remained most faithful to the original intermediate vowels, as will be demonstrated below.
4.4.1 Epenthesised Forms in All Dialects

4.4.1.1 The Stressed Vowel
Recall that epenthesis was, hypothetically, the default process to overcome the blurring effect. Indeed, epenthesis was applied to various (but rather robust) degrees in most dialects. Once epenthesis was introduced, the stressed short vowel retained its original status, and from then on behaved like other instances of the same short vowel in non-blurring environments.

In general it seems that the quality of a stressed short vowel before an epenthesisis-inducing cluster was maintained throughout the generations up until the contemporary dialects. For example, the word *dearg* ‘red’ is variously realised as [ḍarəg], [ḍəɾəg], [dʒəɾəg] or [dʒəɾəg] in the different dialects of Irish and Scottish Gaelic.

In any contemporary case where the quality of a stressed short vowel before an epenthesised cluster is unfaithful to the historical vowel quality, it is due to general dialectal trends regarding this vowel quality. It is beyond the remit of this thesis to describe the later developments and trends of short vowels in Irish.

4.4.1.2 The Epenthetic Vowel
The epenthetic vowel is realised as target-less in most contemporary dialects of Irish (Ó Siadhail 1989:20), and as a reduplication of the preceding stressed vowel in most dialects of Scottish Gaelic (Watson 1994:671). It is beyond the remit of this thesis to decide which of the two options is the original and which a later development.

With regard to the reduplication option, it might be the case that reduplication (target echoing), which as mentioned in section 2.3.2.2.3, facilitates recognition of the target. However, it might also be the case of arbitrary feature filling of a target-less sound. It is again beyond the remit of this thesis to decide which of the two motivate#es this quality reduplication in Scottish Gaelic.
Finally, according to Ó Siadhail (1989:27-28), in certain lexical items that involved epenthesis, stress shifted to the epenthetic vowel and the originally stressed vowel was deleted. For example, in the word *bolgam* ‘mouthful’, which is retained as [bɔ̃gɔম] in the Southern dialect, stress shifted Western dialect, where this word is realised as [bɔλgɔм]. Such instances of stress-shift occurred with other lexical items in other dialects. Ó Siadhail (1989:28) mentions that in such cases, the quality of the original stressed vowel is typically preserved in the currently stressed syllable.

It might be the case that such words involved **vowel-sonorant to sonorant-vowel metathesis**, rather than **epenthesis**, and that such metathesis is yet another conspiratory mechanism to overcome the **blurring effect**.

If they still involved epenthesis, stress shift and subsequent vowel deletion, as Ó Siadhaí suggests, it might be the case that the epenthetic vowel was a copy of the original vowel, as in Scottish Gaelic. It could of course be the case that the epenthetic vowel was originally target-less, and received the quality of the preceding vowel only later, when the preceding vowel was deleted, precisely as Ó Siadhaí suggests.

Regardless of the actual mechanism involved, as the quality of the original vowel was maintained, these lexical developments do not conflict with the idea that preservation of vowel quality and overcoming the **blurring effect** were guiding constraints in the formation of epenthesis.

### 4.4.2 Later Developments in the Southern Dialect

#### 4.4.2.1 The Lengthened Vowels

From the surface forms in the contemporary Southern dialects, it seems that further lengthening was by and large implemented as diphthongisation. Even in the case of the lengthened high vowels, certain Southern sub-dialects developed diphthongs rather than long high monophthongs. Recall that if all intermediate vowels were
further lengthened by diphthongisation, the surface forms would be:

Table 4.4: Lengthening by diphthongisation in the Southern Dialect.

<table>
<thead>
<tr>
<th>Lexical Item</th>
<th>Underlying Form</th>
<th>Lengthen to a diphthong</th>
<th>More Standard Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>cam ‘crooked’</td>
<td>/kɐm/)</td>
<td>[kɐw)m]</td>
<td>[kɐum]</td>
</tr>
<tr>
<td>aimsir ‘weather’</td>
<td>/a)m/)</td>
<td>[a]j)m/)</td>
<td>[a]jm)</td>
</tr>
<tr>
<td>lom ‘bare’</td>
<td>/l)m/)</td>
<td>[l]j)m/)</td>
<td>[l]jm)</td>
</tr>
<tr>
<td>greim ‘bite’</td>
<td>/pr)m/)</td>
<td>[p]e)m/)</td>
<td>[pe)m]</td>
</tr>
<tr>
<td>im ‘butter’</td>
<td>/r)m/)</td>
<td>[r]jm/)</td>
<td>[r]m)</td>
</tr>
<tr>
<td>tum ‘Dip!’</td>
<td>/t)m/)</td>
<td>[t]j)m/)</td>
<td>[t]m)</td>
</tr>
</tbody>
</table>

As mentioned earlier, the high diphthongs [ii] and [uu] were most likely to become monophthongs, as indeed happened in most Southern dialects. However, in the two geographical extremities of the Southern dialect, namely Ring in the south-east and South Clare in the north-west, the contemporary realisations of the lengthened high vowels are diphthongs, typically [ei] and [ou] ([eim] and [toum] in the examples mentioned). The fact that in these two dialects a ternary contrast among the diphthongs (front [ii ei ai], back [uu ou cu]) did not survive is hardly surprising, and if faithfulness to the transient vowel quality were to be maintained in these two sub-dialects at any cost, it is not surprising that it was the high diphthongs [ii ou] that were given up and merged into other diphthongs. The importance of the forms in Ring and South-Clare is as follows: because they form the two opposing geographical borders of the dialect, the fact that the lengthened high vowels are nevertheless identically realised as diphthongs supports the hypothesis that diphthongisation was the original implementation of further lengthening of all intermediate vowels in the Southern dialect. In the non-peripheral sub-dialects of the Southern dialect, the high diphthongs eventually developed into long monophthongs, and the resulting sub-system of fully lengthened vowels was [i: ei ai ou ou:].
The 20th century sub-dialect of West Muskerry maintains this sub-system, and is thus faithful to the original quality of the intermediate vowels in Early Modern Irish, with few lexical exceptions. The following examples are taken from Ó Cuív (1944):

Table 4.5: Lengthened vowels in the Southern sub-dialect of West Muskerry.

<table>
<thead>
<tr>
<th>Lexical Item</th>
<th>Early Modern Irish Form</th>
<th>West Muskerry Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>cam ‘crooked’</td>
<td>[kɑːm]</td>
<td>[kɑum]</td>
</tr>
<tr>
<td>aimsir ‘weather’</td>
<td>[aɪmʃəɾ]</td>
<td>[aɪmʃəɾ]</td>
</tr>
<tr>
<td>lom ‘bare’</td>
<td>[lɔm]</td>
<td>[lɔum]</td>
</tr>
<tr>
<td>greim ‘bite’</td>
<td>[ɡɹεm]</td>
<td>[ɡɹεm]</td>
</tr>
<tr>
<td>im ‘butter’</td>
<td>[ɪm]</td>
<td>[ɪm]</td>
</tr>
<tr>
<td>tum ‘Dip!’</td>
<td>[tʊm]</td>
<td>[tʊm]</td>
</tr>
</tbody>
</table>

The corresponding lengthened vowels before originally tense coronal sonorants or relevant consonantal clusters typically have corresponding qualities. With these forms of the sub-dialect of West Muskerry the discussion of the vowel forms in the blurring-effecting environments in the Southern dialect is concluded. As faithfulness to the original vowel quality despite a blurring environment was the constraint underlying the repair-mechanism of vowel lengthening, and as both the mechanism was applied and the original vowel quality was maintained, yielding the forms attested in this dialect, the analysis is descriptively (and I believe also explanatorily) adequate.

In other Southern sub-dialects, further changes affected the vocalic system to the extent that transparent one-to-one mapping of the qualities of the original short and later intermediate vowels to the contemporary long vowels is no longer possible. However, this is rather predictable given the universal instability of vowel qualities

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45 Although before [ɾC] clusters these vowels are typically realised as monophthongs, e.g. bord ‘table’ [bɔɾd]. This fact has been accounted for by Cyran (1997), and is indeed not surprising given the fact that secondary articulation is absent for ‘broad’ /ɾ/ and that the ‘broad/slender’ contrast is neutralised for /ɾ/ cluster-initially in the Southern dialect (Ó Cuív 1944:50, Breatnach 1947:54).
and vowel systems, and ‘the bridge to the past’ in the forms of the sub-dialect of West Muskerry is sufficient.

### 4.4.2.2 Lengthening and Loss of Lax/Tense Contrast among Sonorants

Recall from section 3.2.1.3.1 that the contemporary Southern dialect has practically lost the lax/tense contrast among coronal sonorants, and that the articulatory gestures of the coronal sonorants in this dialect involve normal effort and duration. As a result, scholars typically categorised the coronal sonorants of the Southern dialect as lax. As the lax/tense contrast is historically related to the singleton/geminate contrast, and as it is the geminate character that was given up, many scholars treated the development of long vowels before originally tense sonorants, as in the following examples, as **compensatory lengthening** (e.g. Ó Baoill 1980, Ní Chiosáin 1991, Williams 1994, Cyran 1997).

**Table 4.6: Vowel lengthening and loss of tense coronal sonorants (Southern Dialect)**

<table>
<thead>
<tr>
<th>Lexical Item</th>
<th>Pre-lengthening Form</th>
<th>Post-lengthening Form (West Muskerry)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>tóm</em> ‘wave’</td>
<td>[t’óʊn̪]</td>
<td>[t’óʊn̪]</td>
</tr>
<tr>
<td><em>teinn</em> ‘ill’</td>
<td>[t’éi̯n̪]</td>
<td>[t’éi̯n̪]</td>
</tr>
<tr>
<td><em>poll</em> ‘hole’</td>
<td>[p’oʊl̪]</td>
<td>[p’oʊl̪]</td>
</tr>
<tr>
<td><em>cill</em> ‘church’</td>
<td>[k’i̯l̪]</td>
<td>[k’i̯l̪]</td>
</tr>
</tbody>
</table>

In quasi-formal terms, all these analyses typically contended that the original tense sonorant was moraic and/or occupies two skeletal positions, while the preceding short vowel was mono-moraic and/or occupies one skeletal position; lengthening is compensatory in the sense that it involves the transfer of a mora and/or a skeletal position from the sonorant to the preceding vowel. Such analyses are observatorily and descriptively adequate as far as lengthening in stressed syllables in the contemporary Southern dialect is concerned, but there is plenty of evidence that such accounts are only partial for the contemporary dialects
and also insufficient for the historical development:

- From a historical point of view, there is evidence that the lax/tense contrast was lost in the Southern dialect only during the 17th century (Williams 1994:448), that is, after the development of full lengthening, which, as mentioned in section 4.1.3, dates to mid 16th century.

- Lengthening takes place before sonorant-initial clusters, e.g. [rd] where there is no reason to suppose that the post-vocalic sonorant is a geminate.

- If the transfer of a mora and/or a skeletal position is the case, it is not clear why it does not occur when the tense sonorant is intervocalic (e.g. geallaim ‘I promise’, originally [jällaim] and contemporarily [jälaim] in most Southern dialects) or when the tense sonorant is in coda position of an unstressed syllable (e.g. capall ‘horse’, originally [kapll] and contemporarily [kapll] in most Southern dialects).

Finally, there is positive evidence that while lengthening took place, contrast was still maintained. Once such piece of evidence is the consistent realisation of the originally tense ‘slender’ coronal nasal /n/ as a palatal [j], which is distinct from the lax ‘slender’ coronal nasal [n]. Lengthening does take place before [j] but not before [n], e.g. (Ó Cuív 1944): binn ‘melodious’ [bijn], buin ‘Reap!’ [bün]. Hence, the tense quality of the sonorant must have been preserved despite lengthening. In this case, it may be argued that the lengthening is still compensatory, and that [j] was the singleton surface realisation of an

46 That vowel lengthening fails to take place before an originally tense sonorant in an unstressed syllable is also attested by the fact that the vowel fails to attract stress to the second syllable. As mentioned in section 3.2.2, a long vowel in the second syllable always receives primary stress in the Southern dialect.
underlying geminate [\textipa{d}]\textipa{d}. Such a claim, however, would collapse in view of the data on the originally tense lateral in the Southern sub-dialect of Ballymacoda: Ó Cuív (1951:66-68) provides a detailed description of the modern ‘incarnation’ of the original tense coronal lateral, both ‘broad’ and ‘slender’, which is also evident in Wagner(1958). In this particular sub-dialect, practically all postvocalic instances of the original post-vocalic tense ‘broad’ and ‘slender’ laterals, both in coda position and inter-vocalically, both in stressed and unstressed syllables, are realised as the clusters [\textipa{d}d\textipa{d}] and [ld] respectively.

To mention just few examples directly from Ó Cuív (1951:66):

Table 4.7: Ballymacoda [ld] for the original tense lateral.

<table>
<thead>
<tr>
<th>Lexical Item</th>
<th>Southern Form</th>
<th>Ballymacoda Form</th>
<th>Northern Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ball ‘body organ’</td>
<td>[b\textipa{d}f]</td>
<td>[b\textipa{d}f\textipa{d}]</td>
<td>[b\textipa{d}f]</td>
</tr>
<tr>
<td>cill ‘church’</td>
<td>[c\textipa{f}]</td>
<td>[c\textipa{f}d]</td>
<td>[c\textipa{f}]</td>
</tr>
<tr>
<td>allas ‘sweat’</td>
<td>[\textipa{a}\textipa{f}a]</td>
<td>[\textipa{a}f\textipa{d}\textipa{a}]</td>
<td>[\textipa{a}f\textipa{a}]</td>
</tr>
<tr>
<td>buille ‘blow’</td>
<td>[b\textipa{i}f\textipa{a}]</td>
<td>[b\textipa{i}f\textipa{d}\textipa{a}]</td>
<td>[b\textipa{i}f\textipa{a}]</td>
</tr>
<tr>
<td>cèille ‘sense gen.’</td>
<td>[\textipa{c}f\textipa{a}]</td>
<td>[\textipa{c}f\textipa{d}\textipa{a}]</td>
<td>[\textipa{c}f\textipa{a}]</td>
</tr>
<tr>
<td>capall ‘horse’</td>
<td>[k\textipa{a}p\textipa{f}\textipa{a}]</td>
<td>[k\textipa{a}p\textipa{f}d\textipa{a}]</td>
<td>[k\textipa{a}p\textipa{f}\textipa{a}]</td>
</tr>
<tr>
<td>Eochaidh (name)</td>
<td>[\textipa{a}x\textipa{f}]</td>
<td>[\textipa{a}x\textipa{d}]</td>
<td>[\textipa{a}x\textipa{f}]</td>
</tr>
<tr>
<td>brothallach ‘sultry’</td>
<td>[b\textipa{r}\textipa{c}h\textipa{a}f\textipa{a}]</td>
<td>[b\textipa{r}\textipa{c}h\textipa{f}d\textipa{a}]</td>
<td>[b\textipa{r}\textipa{c}h\textipa{c}h\textipa{a}]</td>
</tr>
<tr>
<td>buachaill ‘boys’</td>
<td>[b\textipa{u}\textipa{a}x\textipa{f}]</td>
<td>[b\textipa{u}\textipa{a}x\textipa{d}]</td>
<td>[b\textipa{u}\textipa{a}x\textipa{f}]</td>
</tr>
<tr>
<td>codladh ‘sleep’</td>
<td>[k\textipa{a}\textipa{p}\textipa{a}]</td>
<td>[k\textipa{a}\textipa{p}d\textipa{a}]</td>
<td>[k\textipa{a}\textipa{p}\textipa{u}]</td>
</tr>
<tr>
<td>ól ‘Drink!’</td>
<td>[\textipa{o}\textipa{f}]</td>
<td>[\textipa{o}\textipa{f}]</td>
<td>[\textipa{o}\textipa{f}]</td>
</tr>
<tr>
<td>tuile “flood”</td>
<td>[\textipa{t}i\textipa{f}]</td>
<td>[\textipa{t}i\textipa{f}]</td>
<td>[\textipa{t}i\textipa{f}]</td>
</tr>
</tbody>
</table>

It is evident that the [ld] clusters in Ballymacoda correspond consistently to instances of post-vocalic tense laterals in the most conservative dialect in this regard, i.e. the Northern dialect. Hence, it is very unlikely that these [ld] clusters reflect anything but the original geminate or at least the tense nature of the lateral\textsuperscript{47}. Nevertheless, as

\textsuperscript{47} Most probably, it is the geminate nature of the lateral that is preserved by the cluster, but this is not necessarily the case. \textbf{Consonant Fortition} results in clusters as well. For example, word-initial or post-nasal fortition of [z] in Italian yields the affricate (or cluster) [dz], as in zero ‘zero’ [d\textipa{z}\textipa{e}, Lorenzo (a man’s name) [lo.\textipa{ren} \textipa{d}\textipa{z}]. Word-initial glide fortition is very common in the English spoken by native speakers of Spanish or Catalan, resulting in clusters, e.g. \textipa{w}\textipa{h}at [\textipa{gw}\textipa{at}]. Although fortition seems to
pointed out by Ó Cuív (1951:67) and as should be evident to the reader, they do involve lengthening of a preceding short vowel in precisely the same manner and in precisely the same environments as the original tense laterals in the rest of the Southern dialects. If vowel lengthening takes place but the geminate nature of the following consonant remains, lengthening cannot be compensatory. It is therefore most plausible that vowel lengthening before the tense laterals, and indeed in all other cases, stabilised in the Southern dialect (and all other dialects) before, and independently of, the loss of lax/tense contrast.

One last point in this regard is that the intervocalic [ld] clusters do not cause lengthening of a preceding stressed short vowel in Ballymacoda. This seems to be contradictory to the blurring effect hypothesis, as the singleton fully-voiced lateral in coda position is hypothetically blurring. The solution to this apparent problem is simply to assume that the emergence of the [ld] clusters is a later development, which took place after the strict requirement for faithfulness to the original vowel quality, a requirement threatened by the blurring effect, ceased to play a major role in the grammar.

To summarise, I propose that the loss of lax/tense contrast among coronal sonorants in the Southern dialect played no role in the lengthening of preconsonantal originally short and then intermediate vowels, and that this loss of contrast was an independent development which affected the dialect in question only in a later stage.

4.4.3 Later Developments in the Western Dialect

4.4.3.1 The lengthened vowels

From the surface forms in the 20th century Western dialects, it seems that both depend mostly on the segmental and prosodic environment, that the [ld] clusters in Ballymacoda are cases of fortition of a tense consonant, and not splitting of a geminate, cannot be ruled out.
monophthong lengthening and diphthongisation took place. All instances of the original intermediate high and low vowels surface in contemporary dialects as long monophthongs, which are faithful to the historical quality of the intermediate vowel (examples from De Bhaldraini 1945):

Table 4.8: Monophthong lengthening of low and high vowels (Western Dialect).

<table>
<thead>
<tr>
<th>Lexical Item</th>
<th>Early Modern Irish</th>
<th>Cois Fhairrge Form</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>cam</em> ‘crooked’</td>
<td>[kʰəmˠ]</td>
<td>[kʰəmˠ]</td>
</tr>
<tr>
<td><em>aimsir</em> ‘weather’</td>
<td>[aʰmˠafˠ]</td>
<td>[aʰəmˠafˠ]</td>
</tr>
<tr>
<td><em>im</em> ‘butter’</td>
<td>[ɾmˠ]</td>
<td>[ɾmˠ]</td>
</tr>
<tr>
<td><em>tum</em> ‘Dip!’</td>
<td>[tʰu:mˠ]</td>
<td>[tʰu:mˠ]</td>
</tr>
</tbody>
</table>

The qualities of the lengthened high and low vowels in other consonantal environments are similar.

As for the original intermediate mid vowel, it seems certain that it was lengthened to a long monophthong before a tense nasal. However, almost all instances of the original pre-nasal intermediate mid vowel were subject to raising to a high vowel:\footnote{With very few exceptions, e.g. *donna* ‘brown’ [dʰau̯ˠnˠ] and *bheinn* ‘I would be’ [vʰeiːnˠ] (De Bhaldraini 1945).}

Table 4.9: Lengthening of original mid vowels to long high vowels before nasals.

<table>
<thead>
<tr>
<th>Lexical Item</th>
<th>Early Modern Irish</th>
<th>Cois Fhairrge Form</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>lom</em> ‘bare’</td>
<td>[lʰəmˠ]</td>
<td>[lʰəmˠ]</td>
</tr>
<tr>
<td><em>greim</em> ‘bite’</td>
<td>[pʰəmˠ]</td>
<td>[pʰəmˠ]</td>
</tr>
<tr>
<td><em>tonn</em> ‘wave’</td>
<td>[tʰənˠ]</td>
<td>[tʰənˠ]</td>
</tr>
<tr>
<td><em>teinn</em> ‘ill’</td>
<td>[tʰənˠ]</td>
<td>[tʰənˠ]</td>
</tr>
</tbody>
</table>

It is impossible to determine whether this process of raising in the vicinity of a nasal (Ó Siadhail 1989:42-44, Ó hUiginn 1994:546-547), which affected short mid vowels (e.g. *sóna* ‘happy’ [sʰu:nˠə], *moch* ‘early’ [mʰuxˠ]) as well as the long vowel [əː] (e.g. *srón* ‘nose’ [sɾuːnˠ], *mó* ‘biggest’ [mʰuːː]) took place before monophthong...
lengthening or after it.

In non-nasal environments, lengthening of mid vowels took place in the form of diphthongisation:

Table 4.10: Reconstructed lengthening of mid vowels (Western dialect).

<table>
<thead>
<tr>
<th>Lexical Item</th>
<th>Early Modern Irish</th>
<th>Early Western Form</th>
<th>More Standard Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>corr ‘odd’</td>
<td>[kɔr]</td>
<td>[kɔwɛ]</td>
<td>[kour]</td>
</tr>
<tr>
<td>poll ‘hole’</td>
<td>[pɔl]</td>
<td>[pɔwɛl]</td>
<td>[pɔwɛl]</td>
</tr>
<tr>
<td>feil ‘treacheries’</td>
<td>[fɛl]</td>
<td>[fɛjɛl]</td>
<td>[fɛiɛl]</td>
</tr>
<tr>
<td>bord ‘table’</td>
<td>[bɔrd]</td>
<td>[bɔwɛrd]</td>
<td>[bɔwɛrd]</td>
</tr>
<tr>
<td>ceird ‘trade’</td>
<td>[ʃɛrd]</td>
<td>[ʃɛjɛrd]</td>
<td>[ʃɛiɛrd]</td>
</tr>
</tbody>
</table>

Yet again, these forms are not attested in the contemporary Western dialect. A later process merged mid-to-high diphthongs and the low-to-high diphthongs. As the following chart demonstrates, this process affected both original mid-to-high diphthongs (mid-vowel-glise sequences) and the new diphthongs:

Table 4.11: Diphthong merger in the Western dialect of Cois Fhairrge.

<table>
<thead>
<tr>
<th>Lexical Item</th>
<th>Early Western Form</th>
<th>Cois Fhairrge Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>bodhar ‘deaf’</td>
<td>[bɔur]</td>
<td>[bɔur]</td>
</tr>
<tr>
<td>togha ‘choice’</td>
<td>[tou]</td>
<td>[tou]</td>
</tr>
<tr>
<td>feidhm ‘use’</td>
<td>[feim]</td>
<td>[feim]</td>
</tr>
<tr>
<td>leigheas ‘cure’</td>
<td>[lis]</td>
<td>[lis]</td>
</tr>
<tr>
<td>corr ‘odd’</td>
<td>[kour]</td>
<td>[kour]</td>
</tr>
<tr>
<td>poll ‘hole’</td>
<td>[pou]</td>
<td>[pou]</td>
</tr>
<tr>
<td>feil ‘treacheries’</td>
<td>[feil]</td>
<td>[feil]</td>
</tr>
<tr>
<td>bord ‘table’</td>
<td>[bou]</td>
<td>[bou]</td>
</tr>
<tr>
<td>ceird ‘trade’</td>
<td>[ci]</td>
<td>[ci]</td>
</tr>
<tr>
<td>samhradh ‘summer’</td>
<td>[sau.ro]</td>
<td>[sau.ro]</td>
</tr>
<tr>
<td>fadhb ‘problem’</td>
<td>[faib]</td>
<td>[faib]</td>
</tr>
</tbody>
</table>

To summarise, in the contemporary Western dialect the long vowels, which developed from the original mid intermediate vowels, are never faithful to the mid

---

49 Recall that the corresponding forms in the Southern dialect of West Muskerry typically retain precisely these diphthongs, e.g.: [bɔur] [tou] [feim] [lis] [pou] [feil]. Nevertheless, Ó Cuív(1944:30) mentions precisely the same merger in the case of the back diphthongs among the younger generation in West Muskerry.
quality, but both in the case of pre-nasal high long monophthongs, and in the case of pre-liquid low-to-mid diphthongs, these non-mid vowels seem to have resulted from independent and unrelated historical processes.

4.4.3.2 Lengthening and Lax/Tense Contrast among Coronal Sonorants

Recall from section 3.2.1.3.1 that, in the Western dialect, a lax/tense contrast still holds for the ‘slender’ laterals and nasals. This contrast is maintained both in stressed and unstressed syllables. Nevertheless, vowel lengthening does take place before the ‘slender’ tense laterals and nasals only in closed stressed syllables. These facts seem to imply that the lengthening process is not compensatory.

The lax/tense contrast is by and large obsolete for the ‘broad’ laterals and nasals, but this is probably a recent development, as De Bhaldraithe (1945:41) mentions speakers who do maintain this contrast in Cois Fhairrge, and Holmer(1962:40-41) mentions one informant who maintains this contrast in North Clare. For this minority of speakers, vowel lengthening nevertheless applies before the ‘broad’ tense lateral and nasal (see e.g. meall ‘lump’ [m\textipa{\textae}] for these speakers in Cois Fhairrge in De Bhaldraithe 1945:108). This fact again seems to imply that the lengthening process is not compensatory.

In fact, De Bhaldraithe (1945) treats the typically lamino-dental articulation of the coronal lateral and nasal in the Western dialect as tense, and maintains that it is the lax articulation, rather than the tense articulation, that was given up. According to this view, which seems to be widely accepted (e.g. Ó Siadhail 1989:93, Ó hUiginn 1994:560) whenever lengthening takes place before a broad coronal sonorant (hence tense), such lengthening is essentially non-compensatory. However, I prefer not to treat the articulation of the ‘broad’ coronal lateral and nasal in the Western dialect as tense, because this lamino-dental articulation, though definitely involving more
muscular tension and duration than the kind of articulation characterising the
Southern dialect, does not seem to be universally marked, and is attested in e.g.
French and Spanish (see Delattre 1965:89-90) with no lax/tense contrast involved.

4.4.4 Later Developments in the Northern Dialect

4.4.4.1 Vowel Lengthening

Recall from section 3.3.2 that vowel lengthening is very limited in the Northern
dialect. Systematic lengthening is attested only before an original /r/ in coda position
or before the clusters [rdɬ, rlɬ, rnɬ, rdɬ, rlɬ, rnl], only for a low vowel and, with
exceptions, for a back mid vowel. As vowel lengthening depends on vowel quality,
there are cases of vowel length alternations as a result of alternations in vowel
quality, which in turn result from consonantal ‘broad-slender’ alternations. Such
vowel length alternations are essentially non-compensatory. Examples for the sub-
dialect of Meenawania from Quiggin (1906:16,26,97) are: ard ‘high’ [a:rɪɬ], airde
‘highest’ [ɪɬɬd]; ord ‘sledgehammer’ [ɔ:rdɬ], oird ‘sledgehammers’ [ɪrdɬ]; dorn
‘fist’ [ɬdɔrɪ], doirnín ‘handle’ [ɬrɪnl].

The development of truly long vowels from originally intermediate vowels is not
attested in other environments in the Northern dialect, except for sporadic lexical
items, e.g. gallta ‘protestant’ [ɡːɔɬɬ] (but geallta ‘promised’ [jːalɬɬ], thall
‘beyond’ [hɔːɬ] (aside [hɔːɬ], see Ó Rahilly 1932:50). For the possibility that
intermediate vowels are actually retained in the Northern dialect see section 4.4.4.3
below.

As lexical items that involve alternation of vowel length across inflections probably
have a short vowel in the lexical representation, the option of realising the vowel as
short is always accessible for such lexical items. It is therefore impossible to
determine whether such lexical items did involve full lengthening in the Northern
dialect at some historical stage, and later on this lengthening was given up (leaving
some relic forms such as gallta), or whether full lengthening never took place.
It might be the case that the answer lies somewhere between the two options, that is, full
lengthening started to spread gradually through the lexicon, covering the rhotic
environments first, but was blocked during its early stages of spreading to other lexical
environments, due to the emerging bias against long vowels in the dialect. As mentioned
in section 3.2.3.1.2, it is very likely that the bias against long vowels in the dialects of
Donegal was established a few generations before the 18th century, that is, by the 16th-
17th century, during, or a little after, the establishment of full lengthening of intermediate
vowels. As this development sporadically also affected stressed long vowels, it might
have been the central factor in preventing full lengthening from spreading.

4.4.4.2 Syllable Timing, and Devoicing of Lax Sonorants in Coda
Recall from section 3.2.3.3 that the disfavouring of long vowels in the Northern dialect is
probably related to the emerging tendency towards syllable-timing instead of stress-timing.
It is likely that this tendency had an effect on monosyllabic words containing a short
vowel followed by a lax sonorant as simple coda. The following discussion explores
this effect, and for the sake of illustration and clarity it contains superficial
stipulations vis-à-vis the durations of sounds, syllables and stress-units:

- **In a stress-timing system** (see Laver 1994:529), there is a tendency to keep the
temporal intervals between consecutive stress units, or feet, roughly equal.
Assuming that inter-stress intervals are measured between the beginnings of
consecutive stressed rhymes (i.e. the beginning of the stressed vowels), and given
that stress is typically word initial in Irish, then, after a stressed monosyllable, the
next stress is likely to fall on the following syllable, and the only additional material
for the inter-stress interval is the onset of the following syllable. Assuming, arbitrarily, a prototypical foot in Irish, which is disyllabic, containing one long stressed vowel and one short unstressed vowel, and three consonants on average, the typical duration of such a foot would be about 400-450ms. A lexical (i.e. stressed) monosyllabic word containing only a short vowel and a lax sonorant as simple coda, has a rhyme of less than 150ms. As even a tri-consonantal onset would not exceed 170ms, the inter-stress interval would not exceed 320ms, and is actually likely to fall far below it. In such a case, a stress-timing system would react by marginally lengthening the syllable, and assuming that all segments in the syllable are lengthened proportionately, this lengthening affects the vowel as well.

- **In a syllable-timing system** (Laver 1994:528), there is a tendency to keep the temporal intervals between consecutive syllables roughly equal. The prototypical syllable would be about 200-225ms long. Assuming that inter-syllable intervals are measured between consecutive rhymes, then, given a 130-

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50 The contour between stressed and unstressed syllables within the prototypical foot is widely accepted among phonologists, and so is the tendency to a correspondence between a stressed syllable and a long vowel and between an unstressed syllable and a short vowel. Such a stress-unit happens to coincide with Ní Chiosáin’s (1999) optimal word in Irish, which is di-syllabic, and contains a stressed long vowel in the first syllable and an unstressed short vowel in the second syllable. Notice that the cross-linguistic domain for stress is typically the lexical word, as is evident from the fact that contrastive stress placement for primary word stress is very common in languages, whereas secondary, or word-internal, stress placement, is typically automatic and non-contrastive. Thus, Ní Chiosáin’s optimal word happens to correspond to the optimal stress domain in Irish, which is the stress unit assumed here. Given the phonotactics of Irish, except for rare cases, such di-syllabic words can have 1-7 consonants, e.g. óige ‘youth’ [ɔ:jo] – sceondrach ‘elated’ [ʃlɔːn.ɾəræx], with a more likely range of 2-5 consonants, e.g. mála ‘bag’ [m̩la:Jo] – clársach ‘harp’ [kl̩rəʃax] and an average of 3 consonants, i.e. bríoga ‘shoes’ [bɾ̩ɾ̩oːga]. Assuming (for connected speech) about 150-170ms for a long stressed vowel, 60-80ms for a short unstressed vowel, and an average of 60-70ms for a consonant, the resulting stress unit is about 400-450ms long.

51 Duration adjustments seem to affect all segments in the utterance proportionally and are, in general, rather marginal, and do not compensate fully to match the exact timing unit. Nootboom (1997:657) shows data from Nooteboom’s (1972) experiments on vowel duration in reiterant spoken Dutch, a typical stress-timing language. The duration of the first stressed vowel [a] in the disyllabic utterance [ma.mam] was on average 90ms, out of 530ms duration of the utterance. In the monosyllabic utterance [mam], the vowel was 110ms long, out of 410ms duration of the utterance. Similar lengthening affected also the prevocalic and postvocalic [m]. Assuming that the prototypical stress unit is disyllabic, it is clear that lengthening takes place in monosyllables, but also that this lengthening is marginal and does not exhaust the typical duration of the timing unit.
150ms time-frame of a stressed rhyme containing a short vowel followed by a lax sonorant, additional 60ms of a following onset would make the inter-syllable interval almost prototypical, and if the following onset is complex, which is frequent word initially in Irish, the inter-syllable interval is exhausted. In any case, lengthening of the monosyllabic word is rather unnecessary, and the vowel would remain short 53.

Thus, whereas in a stress-timing dialect, automatic lengthening is likely to apply to a short vowel in monosyllabic words ending with a lax sonorant, in a syllable-timing dialect such lengthening is not likely. The following figure illustrates this difference schematically:

Figure 4.1: The effect of stress-timing and syllable-timing on a monosyllabic word containing a short vowel followed by a lax sonorant as simple coda.

The automatic lengthening in a stress-timing dialect may help the lengthened vowel overcome blurring by the following sonorant (although the sonorant is lengthened as

53 Ní Chiosáin (personal communication) raises a question about my prediction concerning circumstances in which the consonantal material following the vowel in question is very short, and is particularly concerned with the form *[C_v^n=V*] e.g. *bun abhann* ‘mouth of river’ *[b^w^n=a_u^n]*. Such cases, however, do not arise in the Northern dialect, in which a word-initial stressed vowel is always preceded by a strong and rather lengthy glottal stop. In the recordings made with Éamonn Ó Domhnaill, a glottal stop preceded each and every instance of word-initial stressed vowel (e.g. *sról adhmad* ‘satin-wood’ *[s^w^o^l_a_d^h^m^a^d]*, *cliabhán éan* ‘bird-trap’ *[k^l^a^b^h^a^n_e^a_n]*, *lucht airneáil* ‘night visitors’ *[l^u^c_t^a^r^n_e^a^_n^a_l]*), and even morpheme-initial stressed vowel in compounds (e.g. *sláinteolaí* ‘hygienist’ *[s^l^a^i^n_t^e^o^l^a^i]*). In all these cases the glottal stop was about 70ms long. My prediction with regard to the form in question is therefore that e.g. *bun abhann* is pronounced *[b^w^n=a_u^n]*, and the inter-vocalic material remains long enough to meet the time-frame, with no need for lengthening.
well), but in a syllable-timing dialect, where automatic lengthening does not take place, the vowel is still subject to *blurring* by the following sonorant. This susceptibility to *blurring* may result in the application of a repair mechanism that would reduce the level of *blurring*. There are three major options for such a repair mechanism:

- Lengthening of the vowel and thus reducing its susceptibility to *blurring*, in a fashion similar to other *pre-sonorant lengthening*.
- Splitting the vowel and the sonorant across syllable domains by *post-sonorant epenthesis*.
- Devoicing of the sonorant and thus reducing its *blurring* potential, as in the case of the *muting effect of a post-sonorant pre-aspirated voiceless stop*.

The first two options seem to be disfavoured in the Northern dialect: vowel lengthening is contradictory to the emerging bias against long vowels. Epenthesis is in general less applicable in the Northern dialect, and as mentioned earlier, word-final epenthesis involves a high risk of the emergence of homophones, especially in monosyllabic words.

Thus, it is the third option, which is chosen, and the result is the devoicing alternations described in section 3.3.3. For an application algorithm see 4.4.4.4 below.

If devoicing is applied in order to reduce the *blurring* potential of a lax sonorant, the inevitable question is, why isn’t it applied also in order to reduce the *blurring* potential of a non-lax sonorant, whose *blurring* potential is even greater due to its longer intrinsic duration?

The answer to this question is that the devoicing of a non-lax sonorant is avoided in the Northern dialect because it contradicts the grammatical requirement of this dialect, that non-lax sonorants be preserved and conveyed despite their articulatory markedness.

Recall from section 2.2 that the acoustic character of a sonorant depends entirely on
formants, or amplified harmonics of the fundamental frequency. When a sonorant is
devoiced, the fundamental frequency is absent, and so are its harmonics. The
resulting sound is a mellow fricative, which is quieter than most voiceless fricative
sounds (because the aperture is larger), and although each such mellow fricative, like
all non-labial voiceless fricatives, has its own characteristic noise formant, this noise
formant is masked by the overall broadband noise.
Devoiced nasals, for example, are merely variants of nasal air-exhalation. The
acoustic and auditory differences between devoiced nasals of various places of
articulation are negligible, and place discrimination depends entirely on the cues
provided by the transition from the preceding vowel. The place cues available from
such transitions tend to be rather poor in the case of postvocalic nasals, compared to
other consonants, because of the effect of anticipatory nasalisation on the auditory
quality of the vowel during the transition (Repp & Svastikula 1988:246). Although in
the case of the non-coronal nasals these cues are poor and unreliable, in the case of
the lax/tense contrast among coronal nasals they are practically non-existent, because
the vocalic transition into both the lax and the tense nasal is very similar.
Thus, whereas nasal exhalation is probably identifiable as nasal, and whereas the
secondary ‘broad/slender’ quality of a final devoiced nasal consonant is probably
identifiable by the front/back quality of the preceding vowel, the place of articulation of
such a nasal is obscured, and the hearer is most likely to perceive any nasal exhalation
as if it involved the default, apico-alveolar coronal articulation. Active devoicing of any
non-default nasal, and first and foremost the tense coronal nasal, is therefore
grammatically senseless, and should be avoided by any grammar that requires and
implements delicate contrasts between nasals with different places of articulation.
In the case of the devoicing of laterals, the auditory contrast among the various
devoiced laterals is somewhat stronger than the contrast between the different variants of nasal exhalation, and resembles more the contrast between various voiceless fricatives. Nevertheless, the overall quietness of these mellow lateral fricatives and the broadband nature of the resulting noise obscure the auditory distinctiveness of the highly marked lax/tense contrast, and it would again be senseless if a grammar both insisted on maintaining such a marked articulatory contrast among the laterals and such marked articulatory gestures for the tense laterals, and also deprived this articulatory contrast from an auditory manifestation.

Finally, in the case of the devoicing of rhotics (Quiggin 1906:95 does mention cases of systematic retention of a long trill, which does not follow a long vowel, e.g. corr ‘odd’ [kɔr]), it seems that the devoicing of a long trill, while probably not affecting its auditory distinctiveness, would also not reduce its blurring potential.

Recall from section 2.3.2 that the blurring potential depends on the co-articulatory colouring potential, as well as on the backward masking potential, which, in turn, depends on the loudness of the sonorant and on the categorical similarity between the masker and the target. As for the co-articulatory colouring potential, this potential is essentially identical for both the voiced and the devoiced variant of the trill (or any other sonorant), because the anticipatory articulatory gesture involved is identical. As for the loudness potential, it seems that the aspiration pulses during a devoiced trill have more or less the same intensity as the vowel-like pulses during a voiced trill. The following oscillogram and spectrogram of the sequence [ɔrɔrɔ] articulated by the author clearly demonstrate this. Notice the rather similar intensity of both trills in the oscillogram and in black line on the spectrogram, and also the vowel-like pulses during the voiced trill as opposed to the aspiration pulses in the devoiced trill on the spectrogram:

Figure 4.2: Oscillogram and spectrogram comparing voiced and voiceless trill.
Whereas the categorical similarity to the vowel is greater in the case of a voiced trill, because of the vowel-like pulses (as opposed to aspiration pulses), the perceived loudness is greater in the case of the devoiced trill, because broadband noise is perceived as louder than a complex tone with the same intensity (Zwicker, Flottorp & Stevens 1957). Hence the backward masking potential of both the voiced and the devoiced trill is roughly the same.

To summarise, it seems that for all non-lax sonorants, devoicing is not an appropriate grammatical solution for resolving their very high blurring potential, and the solution should be sought elsewhere.

4.4.4.3 Possible Retention of Intermediate Vowels Before Tense Sonorants

Recall from section 3.3.2 that, except before original /r/ and sometimes before /rC/ clusters, lengthening fails to take place in the Northern dialect, and a stressed short vowel remains allegedly short before the various blurring post-vocalic environments.

At least with regard to vowel quality, this is indeed the case: The qualities of such vowels are identical to the qualities of corresponding short vowels in other environments,
and do not merge qualitatively with any of the long monophthongs or diphthongs\textsuperscript{54}. With regard to **vowel quantity**, however, there are certain facts which imply that the situation is more complex:

In monosyllabic words containing a short vowel and a sonorant as simple coda, there is a **quantitative contrast** between a vowel preceding a lax sonorant and a vowel preceding a tense sonorant. Thus, in a minimal pair such as *geal* ‘clear’ [\textipa{\textipa{[j]a\textipa{l][b]}}] vs. *geall* ‘pledge’[\textipa{\textipa{[j]a\textipa{l][v]}}] involves not only an articulatory contrast between the devoiced apico-alveolar lax lateral and the fully voiced lamino-inter-dental tense lateral, but it is also the case that the vowel preceding the lax lateral is **shorter** than the vowel preceding the tense lateral.

The dialect descriptions that discuss this matter, e.g. Evans (1969:20-21), contend that the short vowel in question is **over-short** before a lax sonorant (whereas it has ‘normal’ short duration before any other consonant including tense sonorants). However, as these descriptions rely on an impressionistic interpretation of the data, and not on a systematic spectrographic study, and as vowel duration is affected by many factors, including (a) vowel quality, (b) preceding consonantal environment, (c) following consonantal environment, and (d) position in the intonation phrase, their contention that it is the **over-shortness** that is unique is rather unreliable.

Ni Chasaide (1999:114) makes precisely the same claim, but upon my inquiry, Ni Chasaide (personal communication) admits that this over-shortness of short vowels before lax sonorants is in comparison with the duration of the same short vowels before corresponding tense sonorants, as is evident from Ni Chasaide (1979), and that a comparative study of the durations of short vowels across all coda consonants in the

\textsuperscript{54} Unless the quality of the short vowel is identical to the quality of the long vowel. This is the case for [\textipa{\textipa{\textipa{ʃ}}}]/[\textipa{\textipa{\textipa{ʃ}}}], but not for the other vowels.
Northern dialect has never been carried out.

My own impression from both Ni Chasaide’s illustrations as well as from the recordings with Eamonn Ó Domhnaill, both native speakers of Gaeth Dobhair Irish, is that, while there is a clear quantitative contrast between the shorter vowel duration in *geal* ‘clear’ [jæl] and the longer vowel duration in *geall* ‘pledge’ [jaːl], there is no ‘over-shortness’ in the former, compared to syllables with other codas. It thus might be the case that short vowels are actually longer before tense sonorants, and as such, the Northern dialect might be preserving the original intermediate vowels, which are identical in quality, but somewhat longer in quantity, than short vowels in other environments.

This limited vowel lengthening before tense sonorants is thus a last resort repair mechanism: Final epenthesis is blocked because of the risk of homophones, sonorant devoicing is blocked because of its lack of auditory faithfulness which is essential in the case of the marked non-lax sonorant (or because of its uselessness in the case of a trill), and full lengthening is blocked because of the bias against long vowels. Thus vowel lengthening takes place to the maximal extent permitted as long as the vowel duration is still shorter than the perceptual threshold for a long vowel category, and the grammatical price is the perceptual quantitative contrast between a short (or over-short) vowel before a lax sonorant and an intermediate (or short) vowel before a tense sonorant, yielding a ternary quantitative contrast for stressed vowels in the Northern dialect, as was the case in Early Modern Irish.

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55 In the two recordings of the phrase ‘a ngeall geal’ ‘their clear pledge’ [aːnæl] the average duration of the [a] vowel in the word ngeall was 220ms, substantially longer than the 180ms average duration of the [a] vowel in the word geal, especially given the fact that geal was utterance-final, a position where vowels typically lengthen. However, this 180ms average duration is by no means an over-short duration for utterance final [a]. For example, in two recordings of the phrase ‘tháirg sí talc’ (‘she produced talc’) [tæɾʃiˈlːk], the average duration of the utterance-final [a] was only 150ms.
4.4.4.4 Informal Application Algorithm

Following is an informal application algorithm for devoicing of lax sonorant and limited vowel lengthening before a tense sonorant:\textsuperscript{56}

Table 4.12: Sonorant devoicing and partial vowel-lengthening (Northern dialect).

<table>
<thead>
<tr>
<th>Lexical Item</th>
<th>cor ‘twist’</th>
<th>corr ‘odd’</th>
<th>mill ‘honey’</th>
<th>mill ‘Destroy!’</th>
<th>geal ‘clear’</th>
<th>geall ‘pledge’</th>
<th>bun ‘base’</th>
<th>bonn ‘sole’</th>
<th>mhin ‘meal’ (lenited)</th>
<th>bhinn ‘peak’ (lenited)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underlying Form</td>
<td>/kɔ/</td>
<td>/kɔr/</td>
<td>/mɪl/</td>
<td>/mɪl/</td>
<td>/jɔl/</td>
<td>/jɔl/</td>
<td>/bɔ́r/</td>
<td>/bɔ́r/</td>
<td>/nɪl/</td>
<td>/nɪl/</td>
</tr>
<tr>
<td>Stress-Timing Form</td>
<td>[kɔ]</td>
<td>[kɔr]</td>
<td>[mɪl]</td>
<td>[mɪl]</td>
<td>[jɔl]</td>
<td>[jɔl]</td>
<td>[bɔ́r]</td>
<td>[bɔ́r]</td>
<td>[nɪl]</td>
<td>[nɪl]</td>
</tr>
<tr>
<td>Syllable-Timing Form</td>
<td>[kɔ]</td>
<td>[kɔr]</td>
<td>[mɪl]</td>
<td>[mɪl]</td>
<td>[jɔl]</td>
<td>[jɔl]</td>
<td>[bɔ́r]</td>
<td>[bɔ́r]</td>
<td>[nɪl]</td>
<td>[nɪl]</td>
</tr>
<tr>
<td>Problematic?</td>
<td>Yes – all these forms are problematic because the dialect develops a syllable-timing system.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

With regard to monosyllables ending with non-coronal nasals, e.g. \textit{am} ‘time’ [cɪm], \textit{im} ‘butter’ [ɪm], \textit{long} ‘ship’ [lɔŋ], \textit{ding} ‘wedge’ [dɪŋ], this algorithm predicts that...

\textsuperscript{56} The diacritic ['] indicates the duration of a short vowel unaffected by stress-timing lengthening. The forms of a monosyllable ending with a tense sonorant are presumably identical in both stress-timed and syllable-timed systems because the rhyme is long enough. Devoiced-sonorant forms are problematic if the sonorant is tense because of auditory unfaithfulness in the case of a lateral or nasal, and because of ineffectiveness of the devoicing in the case of a trill. Partially lengthened forms are not applicable for monosyllables ending with a lax sonorant, as the forms with sonorant devoicing are preferred.
devoicing is again impossible, because devoicing impedes place recognition for nasals. As these nasals are somewhat shorter than the tense coronal nasals, the lengthening needed to overcome the *blurring effect* is more limited than in the case of the tense coronal nasal. As there is no reliable comparative data concerning vowel duration before the various nasals in this dialect, I prefer not to include such words in the chart, because I do not know whether the algorithm successfully predicts the data.

### 4.5 A Comment on the Stability of Stressed Short Vowels across Dialects

The *blurring effect* hypothesis predicts that if substantial blurring of vowel quality is not compensated by any repair mechanism, the pressure on the vocalic system would cause instability to the system. Across the contemporary dialects of Irish, there seems to be a correlation between the presence of tense sonorants and/or the absence of counter-*blurring* repair mechanisms, and the instability of the system of stressed short vowels:

- In the Southern dialect, where the various repair mechanisms are obligatory and most tense sonorants are obsolete, the system of short vowels seems rather stable, with no quality mergers and only limited idiosyncratic free variation in vowel quality.

- In the Western dialect, some of the repair mechanisms are optional (Ó Siadhail 1989:49,52), and tense sonorants are still present. More particularly, as the course of neutralisation among the ‘broad’ coronal sonorants seems to have resulted in generalised ‘half-tense’, rather than lax articulation, the pressure on short back vowels increased accordingly. Indeed, some quality neutralisation seems to have taken place, in certain environments, among the non-low back vowels [o] and [ɔ] in this dialect.

- In the Northern dialect, where the tense articulation of sonorants is present but not generalized and the application of the repair mechanisms is more limited
than the other dialects, a great deal of instability, free-variation and merger is attested among the back vowels. Hughes (1994:627) mentions that the three qualities [ɣ ɔ ø] are rather interchangeable, and that [ɣ] and [ɔ] are possibly in complementary distribution.

This circumstantial correlation between the level of alleged pressure by sonorants on preceding short vowels and the instability of short vowels is indeed interesting, but it would be rather rash to claim that the quality neutralisation or interchangeability in the Western and Northern dialects is directly related to the alleged greater pressure exerted by the sonorants in these dialects.

4.6 Previous Theoretical Accounts

Previous accounts of the same phonological alternations did not take the blurring effect or other auditory considerations into account. Some of them, however, did treat the conspiratory nature of the epenthesis and lengthening alternations. In what follows some of these previous, alternative accounts, are presented, and the fundamental differences between them and the current account are highlighted.

4.6.1 Ó Baoill (1979, 1980)

In Ó Baoill (1980) we find an informal, unified theoretical account for the epenthesis and lengthening alternations, as well as for pre-aspiration of post-vocalic and post-sonorant voiceless stops in Scottish Gaelic. The account in the case of lengthening is essentially the same as the account for lengthening in Ó Baoill (1979). The motivation for all these alternations, according to this account, is the interaction between weight (morae) preservation, and the avoidance of surface gemination of underlyingly geminate consonants, in all the Gaelic dialects except for the Northern dialect of Irish^57.  

^57 This is more of a constraint-oriented paraphrase of the original rule-based account.
Ó Baoill assigns 2 morae to long vowels, all tense sonorants, all stops, and the fricatives /s f ðv/; and 1 mora to short vowels, all lax sonorants and the fricatives [v/w ʌ x ç ʒ j]. Once a bi-moraic consonant has to give up one of its morae, this mora can be realised either by lengthening of a preceding short vowel, by an independent short vowel (diphthongisation of a short vowel or epenthesis), or as [x] or [h] (as in the case of pre-aspiration in Scottish Gaelic).

This account seems to capture most of the relevant phenomena, leaving only minor data issues unexplained, such as:

- Epenthesis before sonorant-[v] clusters e.g. *doilbh* [dɔll̪ˠə] ‘gloomy’, which seems to increase the overall weight of the word rather than to preserve it.
- Retention of short vowels before obstruents other than voiceless stops in Scottish Gaelic, e.g. *beag* [bɛg] ‘small’. If voiced stops are underlyingly geminates yet surface as singletons (as Ó Baoill suggests), the account predicts that their dangling mora would be realised phonetically, yet this is not the case. In such words, the overall weight is reduced rather than preserved58.

However, the major flaw in Ó Baoill’s account is the unprecedented supposition of robust gemination in the consonant system. According to Ó Baoill, whenever there is no contrast between singleton and geminate instances of a certain consonantal sound, one can freely assume that such a sound is geminate. The empirical evidence for gemination, and hence for this counter-universal supposition is taken from the hyper-articulation of most consonants by Ó Baoill’s and also Wagner’s (1959) informants of the Northern dialect. Unfortunately, hyper-articulation does not necessarily indicate

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58 According to Ó Baoill’s account, it seems that in the Southern and Western dialects of Irish a mora was lost in all words containing a short vowel and an obstruent other than [v x ç]. However, as long as there is no selective repair mechanism, as in the case of his account to Scottish Gaelic, this is not a problem.
gemination. Furthermore, the relative shortness of the lax coronal sonorants compared to other consonants in the speech of his own informant is not unique, and does not seem to involve a singleton-geminate contrast in other languages. For example, Barnes’ (2001) experimental study with Turkish informants shows that, in that language, post-vocalic singleton [t] is twice as long as post-vocalic singleton [r] and [l]. According to Ó Baoill’s method of mora evaluation, the singleton Turkish [t] should have been regarded as geminate, and geminate Turkish [t] should have probably been regarded as double-geminate, with 3 or 4 morae.\footnote{Turkish distinguishes singletons from geminates for all consonants.}

Although Ó Baoill adopts the notion of morae from standard phonological theory, his use of this notion deviates from the common practice of mora-assignment, and whereas his account captures most of the phenomena, it is theoretically inconsistent.

### 4.6.2 Ní Chiosáin (1991)

Ní Chiosáin (1991) proposes a unified account for epenthesis, lengthening before originally geminate (tense) sonorants, and before a voiced obstruent followed by a non-homorganic sonorant, within a metric-moraic framework.\footnote{Ní Chiosáin (1991) is the only one among the accounts presented, including the account developed in this thesis, that accounts for lengthening before obstruent-initial clusters.} The underlying hypotheses and mechanisms in her account are as follows:

- Tense sonorants are underlyingly geminates, that is, lexically moraic.
- Weight-by-position assigns a mora only to coronal sonorants followed by a non-coronal, which is not a voiceless stop.
- Any mora linked to a consonant (either lexically moraic or after the weight-by-position process) is delinked in the phonology.
- A mora preservation constraint forces a delinked mora to associate to a vowel, either by epenthesizing a vowel or by lengthening a short vowel.
In this account there seem to be no dramatic deviation from standard phonological theory. Unlike Ó Baoill’s (1980) account, it assigns morae only to sonorants, be they tense sonorants or sonorants in certain clusters. The only problem in this account is the selectiveness in mora-assignment in clusters, as well as the arbitrariness of mora assignment in those clusters in which lax sonorants are assigned morae. It is not clear why sonorants are assigned morae in certain clusters but not in others, and when they are assigned, it is not clear why this should happen.

4.6.3 Cyran (1997)
Cyran (1997) accounts for lengthening before originally tense sonorants in the Southern dialect within the framework of Government Phonology. Government Phonology makes extensive use of empty (unrealised) slots on the skeletal tier in the segmental representation. For example, a word-final consonant is typically the onset of a syllable with an empty rhyme. A rhyme is regarded as a phonological constituent, which therefore has a nucleus. Just like any other non-empty phonological constituent in Government Phonology, a non-empty rhyme must contain a phonetically realised constituent head, a nucleus in this case, but may contain other slots, such as the complement, which may be empty.

According to Cyran’s account, following a lexically short vowel a tense sonorant in coda position underlyingly occupies two skeletal slots, namely the onset of a following syllable and the rhyme-complement of the preceding syllable, whereas the underlying short vowel occupies only the rhyme nucleus. However, due to certain theoretical government considerations, the consonantal material of the tense sonorant cannot surface in the preceding rhyme-complement, and the skeletal position of the rhyme-complement is filled by a sub-segmental, ‘melodic’ (vocalic) element of either the tense sonorant or the preceding short vowel, to create a diphthong or a long
monophthong respectively (in a manner rather similar to the ‘further lengthening’ proposed in section 4.3.3). If the sonorant is followed by a vowel (i.e. if the following syllable nucleus is non-empty), the rhyme-complement of the pre-sonorant syllable remains empty, and that vowel remains short as a result.

This is far from a comprehensive summary of Cyran’s account, which relies heavily of concepts specific to Government Phonology theory. Suffice to say that Cyran’s representations and processes manage to account for the various realisations of lengthening as diphthongs or long monophthongs before tense sonorants, in a manner by and large faithful to the data in the Southern dialect.

A major problem in Cyran’s account, in my opinion, is that other, very similar, lengthening alternations (pre-cluster lengthening) are ignored. As they are very similar or even identical, they should involve similar representations and mechanisms. It is not clear, for example, whether a lax sonorant, which is initial in a postvocalic consonantal cluster, can occupy the same double skeletal positions as a tense sonorant. In Ni Chiosáín’s (1991) account there is an arbitrary assignment of morae to sonorants (or obstruents) in certain clusters. Arbitrary as this mora-assignment may be, it equalises the weight of certain consonants to that of tense sonorants, and thus creates a single environment in which lengthening or epenthesis take place.

Cyran’s (1997) account does not introduce any metric-moraic considerations, and it remains unclear how his representations can give rise to similar lengthening processes in other circumstances.

4.6.4 Ni Chiosáín (1999)

An Optimality-Theoretic account of the vowel epenthesis phenomenon is given in Ni Chiosáín (1999), based on the following considerations:

- Two (crucially-) equally ranked constraints - one disfavouring foot
construction at the right edge of the prosodic word, the other disfavouring syllables that remain unfooted - create two options for the optimal prosodic word: either bi-moraic or tri-moraic (with a final unfooted light syllable).

- Sonority-distance constraints on consonant clusters crucially disfavour sequences of a sonorant followed by a non-homorganic consonant which is not a voiceless stop. By crucially I mean that the ranking of these sonority distance constraints to a constraint disfavouring epenthesis, and probably (such a constraint is not mentioned) a constraint disfavouring splitting homorganic clusters, results in permissible epenthesis only in such a particular cluster. Because the anti-epenthesis constraint DEP outranks the sonority distance constraint *RK (which militates against clusters comprising of a sonorant followed by a voiceless stop), epenthesis is impossible before such clusters. Other sonority distance constraints, e.g. *RG (which militates against clusters comprising of a sonorant followed by a voiced stop) outrank DEP, and therefore epenthesis is permitted in order to satisfy them. For example, given the word *dearg* ‘red’, with the input form /d\arg/, DEP is violated in order to satisfy *RG, and the output form is [d\ar\g]. Conversely, given the word *dearc* ‘Look!’ , with the input form /d\ark/, *RK is violated in order to satisfy DEP, and the output form is [d\ark].

As a result, mono-moraic and bi-moraic (disyllabic) inputs containing the crucially disfavoured cluster yield, via epenthesis, a bi-moraic and tri-moraic output respectively, but longer inputs are not epenthized (unless they are morphologically complex, maintaining epenthesis as faithfulness to the base).

Counter-evidence to this account is the following: Monosyllabic words containing a long vowel and the disfavoured consonantal cluster are not discussed. Such words
remains monosyllabic in Irish61: táirg ‘produce!’ is pronounced [\(<\text{i}a.r\text{ɾ}]) rather than [\(<\text{i}a.r\text{ɾ}>)], implying that an unfooted syllable is crucially disfavoured compared to a right-edge foot. Therefore, epenthesis should never yield tri-moraic output forms (with an unfooted mora at the right). As such output forms exist in Irish, e.g. airgead ‘money’ [\(<\text{a.r}>)], the proposed grammar is inadequate62.

4.6.5 Additional Comments on these Accounts

4.6.5.1 Objection to the Compensatory-Lengthening Analyses

A common feature of all the accounts dealing with lengthening before tense sonorants is the assumption that they all involve compensatory lengthening. This assumption is widely accepted among most scholars. Nevertheless, there are a few major problems with this assumption:

- It is not clear why compensatory lengthening does not occur before original tense sonorants in unstressed syllables63.
- It is not clear why lengthening fails to occur once a tense sonorant is intervocalic, that is, why, in intervocalic position, an inherent mora or additional skeletal slot occupied by the tense sonorant is ignored.
- At least some of the instances of pre-tense lengthening seem non-

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61 In the following output forms <> mark foot boundaries.
62 In fact, tri-moraic words like airgead [\(<\text{a.r}>)], in which the epenthesis does not affect a word-final cluster, never involve alternations that allude to the epenthetic nature of the vowel, and it can be claimed that in such words the vowel is underlying rather than epenthetic. Ni Chiosáin nevertheless treats such words as epenthesis-inducing, implying that epenthesis can give rise to tri-moraic words. Tri-moraic words like deirge ‘red comp.’ [\(<\text{d}e.r\text{ɾ}>)], which do involve such alternations (compare: dearg ‘red’ [\(<\text{d}a.r\text{ɾ}>)], are always morphologically complex, and Ni Chiosáin’s account specifically permits epenthesis in such cases.
63 One can think of two explanations, but I am not aware of their existence in the literature: (a) Compensatory lengthening, as a mechanism of consonantal mora preservation, is positionally dependent. Positional faithfulness is greater in stressed syllables than in unstressed syllables, and it might be the case that a mora preservation mechanism, which is essentially faithfulness-oriented, is applied only in stressed syllables. (b) Compensatory lengthening lengthens a vowel. The short vowel in unstressed syllables is targetless, and it might be the case that the grammar avoids lengthening of a targetless vowel (e.g. capaill ‘horses’ [\(<\text{k}a.p\text{ɾ}>)] > *\([\text{k}a.p\text{ɾ}])].
compensatory. Thus, in the Western dialect, ‘slender’ tense sonorants (and according to most scholars also ‘broad’ tense sonorants) remain tense after lengthening (e.g. *cill ‘chruch’ [ˈciːl̯]), and in Ballymacoda (a Southern sub-dialect) the original geminate or tense nature is retained for the laterals via [ld] clusters, despite vowel lengthening (e.g. *cill ‘church’ [ˈciːːld̪]). In general, there is great inconsistency among scholars about whether the lax/tense contrast is qualitative, quantitative or both.

- The compensatory nature of pre-cluster lengthening as in e.g. *solas/soilse ['sɒləs/ˈsoilə] ‘light/lights’ is rather controversial. Truly, the longer vowel in the latter might be a compensation for the loss of the second vowel in the former, as proposed in Ní Chiosáin (1991). However, the corresponding forms in the Northern dialect are ['sɒləs/ˈsɒələ], with evidence of weight preservation. As all sources always take the surface data in the Northern dialect as the authentic contemporary evidence for the underlying representation in pre-tense lengthening in the Southern and Western dialects, it seems peculiar that, in pre-cluster lengthening, the Northern dialect is suddenly ignored.

I believe that these problems are reasonable motivation for seeking another explanation, which does not involve weight-preservation or other compensatory considerations. The account presented in this chapter does not depend on such considerations, and therefore stands as an alternative.

4.6.5.2 Dependency on theory-bound concepts
A common characteristic of all the previous accounts, and indeed of the majority of theoretical accounts to phonological alternations in general, is that they all use
elements, constraints and mechanisms, which are abstract stipulations of linguistic
theory. From Ó Baoill’s (1980) extensive mora assignment, through Ni Chiosáin’s
(1991) environment-dependent mora assignments and mora-delinking rules, Cyran’s
(1997) empty rhyme complement slots, to Ní Chiosáin’s (1999) foot-word alignment
constraints, all these entities are abstract concepts which are motivated by the
exploration of linguistic data from a theory-specific point of view, and reinforced by
observation of additional linguistic data from the same theory-specific point of view.
However, being abstract concepts of a **theory of mind**, they are never subject to
experimental validation or falsification.

Throughout the last century, phonological theories have evolved according to
changing trends, and any phonological account which relies heavily on theory-
internal stipulations, risks becoming obsolete once the theory in question has been
superceded. Even the most elegant account within one theory may be unintelligible to
practitioners of other theories.

A theoretical phonological account is more likely to retain validity, despite changing
theoretical trends, the less it relies on theory-internal arbitrary stipulations. In addition, as
scientific validity seems to go hand in hand with experimental validation, the more the
theoretical account relies on measurable elements and on experimentally tested
hypotheses, the more likely it is to retain validity and to appeal to scientific disciplines
which are related to phonology but are outside the immediate circle of phonological and
linguistic theory.

The account presented in this chapter differs from the previous accounts in the sense
that it indeed relies almost entirely on articulatory and auditory properties, which
have been established, or at least suggested, outside the realm of a language-specific
theory of mind (i.e. linguistic theory). This account is based mostly on suggested
properties of the perceptual system, and therefore cannot be directly validated experimentally, because there is no way to measure objectively whether speakers of contemporary Irish actually encounter systematic perceptually-blurred vowel quality, and because nothing at all can be measured with speakers of earlier stages of the language. Nevertheless, it presents detailed claims that can be transformed into material for experiments on perception, and if such experiments are performed in suitable conditions, the plausibility of these claims can be tested. In the best scenario, where all claims are validated experimentally, it may be claimed that the account is at least circumstancially valid, that is, if the real cognitive mechanisms involved were as the account suggests, then the observed data would be the same.

4.7 Summary
This chapter proposed a theoretical account to the phonological alternations presented in chapter 3. This account makes extensive use of the blurring effect hypothesis developed in chapter 2 as a determinant factor, since it suggests that these phonological alternations are products of repair mechanisms that are applied in order to enhance the perception of vowel quality in otherwise blurring circumstances.
As the forms immediately predicted by the repair mechanisms are not always identical to the forms observed in the data of contemporary Irish, various paths of dialectal historical development which nevertheless have external empirical evidence, have been explored to link the forms predicted by the applied mechanisms to the forms observed in contemporary Irish.
Finally, previous theoretical accounts of some of the phonological alternations were discussed, and the major differences between these accounts and the present account highlighted.
5 Experimental Validation of the Blurring Effect

This chapter reports on an experimental study which was carried out in order to provide empirical support to the *blurring effect* hypothesis and its alleged manifestations in Irish. Unfortunately, the time-course of my thesis was such that I was forced to construct and perform these experiments during the early months of my work. At that stage I only had a vague notion of the *blurring effect* hypothesis, only intuition about backward masking, and very limited background on experiments on perception. The experiments reported in this chapter are therefore not fully reliable, and should be regarded as pilot experiments. The results of these experiments nevertheless support most of the hypotheses explored in this thesis, and are therefore very encouraging. I hope that despite the amateur nature of the experiments reported below, the reader will be convinced that by and large they did test the relevant hypotheses appropriately, in the sense that most variables were taken into account and controlled by methods that kept to minimum any side effects, especially side effects which result in a bias towards the acceptance of the hypotheses under examination.

While finishing this thesis I was engaged in constructing a new series of experiments that are more reliable. The time limits for the submission of this thesis prevented me from including this new series of experiments here. The methodology in the forthcoming series of experiments is described in section 5.4 below, and the results will hopefully be reported in papers later on.

This chapter sets off with a discussion for the need of experiments in phonology in general and in this thesis in particular. It then describes the methodology used in the construction of the experiments, and this is followed by reports on the various (specific) experiments. The last section describes the construction of the forthcoming series of experiments, which is intended to compensate for the shortcomings of the series reported here.
5.1 Background

5.1.1 The Need for Experiments in Theoretical Phonology

As part of their introduction to their book, Ohala & Jaeger (1986:1-6) tackle the question of why experiments are actually needed in phonology: most ‘advances’ in linguistic research in the past two generations were merely substitutions of certain arbitrary theoretical labels with other, perhaps more elegant, more consistent, but never less arbitrary labels. Most linguistic research is based upon the linguist’s knowledge of the facts (linguistic data), her creativity (hypotheses), and ability to form logical argumentation (via formal mechanisms or simply informal but adequate explanation). But, as in Ohala & Jaeger’s words: ‘our knowledge of the world is subject to many distortions’, and ‘little progress can be made toward achieving this goal [the search for insight into the nature of the universe] unless care is taken in observing the universe.’

Collected linguistic data in general and phonological data in particular are easily subject to distortion by orthographical bias by the collector or the informant, by the grammatical filters imposed by the collector’s perception grammar, by the rather impressionistic methods typically used in the collection of linguistic data, and often by the finiteness of the data.

Many theoretical accounts of phonological alternations would collapse upon the introduction of additional data or the instrumental (re-)examination of the data, and even when a certain phonological account is based on a profound theoretical idea, and withstands changes in the data, it might become obsolete if the theory within which it was constructed became unfashionable.

Thus, particular accounts may come and go but it is always the linguistic creativity, or hypothesis, that really interest linguists, and it is precisely the interaction between linguistic creativity and experimental validation that turns a hypothesis into a
theoretical insight, or, in Ohala & Jaeger’s words: “Without theory there would be no indication of what to observe and how to interpret it once observed. Aimless data gathering, therefore, does not constitute doing experiments. On the other hand, theory construction … that is not checked and guided by experiment is equally useless, as numerous cases in the history of science reveal to us, for example, the fantasy of Cartesian cosmology.” (Ohala & Jaeger 1986:3-4)

The blurring effect of sonorants, and its alleged role in the various phonological alternations in Irish, remains speculation as long as it is not validated experimentally. The experimental study discussed below was conducted in order to turn this speculation into a more substantial theoretical insight.

5.1.2 Purpose of the Experiments

As stated, the experiments were conducted in order to provide support for the presence of the blurring effect hypothesis, as well as its manifestations in Irish. Thus, the hypotheses in question are:

- Vowel quality is perceived poorly in the case of a pre-sonorant vowel, compared with other instances of the vowel (the major blurring effect hypothesis).
- The perception of the quality of a pre-sonorant vowel is degraded when the sonorant is longer (relevant for vowel lengthening before non-lax sonorants in Irish).
- The perception of the quality of a pre-sonorant vowel is improved when the vowel is longer (relevant for all lengthening alternations in Irish).
- The perception of the quality of a pre-sonorant vowel is degraded by tautosyllabicity of the vowel and the sonorant (relevant for both the lengthening alternations, which are confined to closed syllables, and to the epenthesis
alternations, which render a closed syllable open).

- The perception of the quality of a pre-sonorant vowel is improved when the sonorant is devoiced (relevant both for the sonorant devoicing alternations and for the lack of lengthening when a postvocalic sonorant is passively devoiced by a following pre-aspirated voiceless stop).

5.1.3 Experimenting on Perception

The hypothesised blurring effect of sonorants is a component of the auditory-perceptual system. Supposedly, it alters the acoustic output of a distinct vocalic articulatory gesture and/or make this output less distinct perceptually, compared to the acoustic output of the same distinct gesture in other non-blurring circumstances. Therefore, in order to validate the blurring effect experimentally, a perceptual experiment should be conducted. Such an experiment has to show that perception, or recognition, of vowel quality is significantly degraded in allegedly blurring environments compared with other environments.

Then comes the following question: How can we measure perception? How can we know that a subject recognises or misrecognises the quality of a given vowel? There is no easy answer to these questions, and probably there are no perfect solutions for them. Measuring the precise excitation patterns and pulses of the subject’s basilar membrane and auditory nerves is impossible, and even if it were possible, we wouldn’t know how to interpret it, as long as we have no direct access to the cognitive processing of auditory excitation patterns.

The solution I came up with involved phonetic transcription of nonsense words. Phonetic transcription is a listener’s attempt to report objectively her perception of auditory stimuli. Nonsense words guarantee that sound-recognition (and its reporting) depends only on the acoustic input, the auditory excitation, and its filtering through the
subject’s perception grammar, but not on semantic context or lexical experience.

An utterance involving distinct articulatory gestures of a given vowel carries at least some acoustic cues for the quality of that vowel, even in the most supposedly-blurring environment. That is, if a vowel is articulated ‘properly’, there are good chances that it would be properly recognized (and transcribed) even in blurring environments. Therefore, this degraded recognition of vowel quality in blurring circumstances is expected to result only in a tendency to degraded transcription (more transcription mistakes). This tendency can only be validated statistically, that is, only according to an analysis of a sufficiently large transcription corpus made by a sufficiently large number of human subjects, using valid statistical methods.

5.1.4 Methodology and Rationale

5.1.4.1 Object of Study

The experiments were designed in order to test the presence of the hypothesised blurring effect in the context of its supposed consequences in the phonology of stressed short vowels in Irish.

Recall from section 3.2.3.2 that stressed short vowels in Irish are phonemically distinct only according to a ternary height parameter (vertical tongue position), with horizontal tongue position determined by the consonantal environment and the configuration of the lips determined by both the vowel height and the consonantal environment.

The experiments therefore test only recognition of vowel height, in a manner similar to its manifestation in Irish.

5.1.4.2 Subjects

About 40 first year’s linguistics students, with 10 (weekly) hours of experience in active phonetic transcription, served as subjects in this experiment, which was
conducted weekly during consecutive phonetics lab sessions. Familiar enough with the task of phonetic transcription of nonsense words, they could be trusted to transcribe with reasonable accuracy. Lacking expertise, though, they were doomed to make systematic and statistically substantial mistakes, especially when transcribing problematic stimuli.

The native tongue of the vast majority of subjects was (Hiberno-) English. Five subjects were native speakers of various other languages (German, Spanish and Finnish). Hence, all considerations concerning the role of the perception grammar in the subjects’ performance refer to English-based perception grammar.

5.1.4.3 Subjects’ Awareness
In order to prevent any deliberate or conscious change in the quality of the subjects’ transcription performance, the subjects were kept ignorant of the precise purpose of the experiment, and did not receive any feedback on their performance quality.

5.1.4.4 Performance Method
Subjects were given handouts with numbered gaps and were requested to fill in the gaps with (active) transcription of sequential nonsense words (see 5.1.4.7 below on the stimuli), and to focus their attention on the vowel\(^64\). The master recording of the stimuli was recorded onto audiotapes, which were played to the subjects via earphones.

5.1.4.5 Stable performance quality
In order to minimise the effect of gradual tiredness, a given experiment session lasted for no more than 6 minutes (maximum of 65 stimuli).

In order to minimise the effect of task-initial disorientation, experiment sessions

\(^64\)or on the vowel of the first syllable in the case of a bisyllabic stimulus.
always started with two ‘dummy’ stimuli whose transcription data were ignored.

In order to maintain identical exposure to each sample, stopping the tape and replaying a stimulus was forbidden. Each stimulus (of an average duration of 350ms) was followed by 4.5 seconds of silence, during which the subject transcribed.

5.1.4.6 Experiment Sessions

Each session tested certain parameters independently of other sessions, and could thus be regarded as a separate experiment. However, some sessions are presented and analysed together, as they form distinct parts of a single experiment.

5.1.4.7 Stimuli

5.1.4.7.1 Stimulus Template

The stimuli were mono/disyllabic nonsense words, of the templates: CV, CVC, CVCV, CVCCV. The first vowel was the vowel being examined, and the following consonant or consonantal cluster was the ‘postvocalic material’.

5.1.4.7.2 Vowels under Examination and their Environments

The stimuli contained six distinct vowel qualities, [i e a ø u], all rather centralized (never fully front or back, never fully high or low; mid vowels were more or less pure mid). However, as is the case in Irish, a postvocalic consonant always had secondary articulation (palatalisation or velarisation), and the front/back quality of the vowel (along with unrounded/rounded lip position for non-low vowels) always agreed with the palatalised/velarised quality of the following consonant. Thus, the front vowels [i] [e] and [a] were always followed by a palatalised consonant, and the back vowels [u] [ɔ] and [ɑ] followed by a velarised consonant. The initial consonant was always plain [d].

The following are the postvocalic consonants used in the experiments:
Table 5.1: Postvocalic consonants used in the experiments

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<td>[p']</td>
<td>velarised voiceless bilabial stop</td>
<td>[p]</td>
<td>palatalised voiceless bilabial stop</td>
</tr>
<tr>
<td>[b']</td>
<td>velarised voiced bilabial stop</td>
<td>[b]</td>
<td>palatalised voiced bilabial stop</td>
</tr>
<tr>
<td>[m']</td>
<td>velarised bilabial nasal</td>
<td>[m]</td>
<td>palatalised bilabial nasal</td>
</tr>
<tr>
<td>[p']</td>
<td>velarised voiceless labio-dental fricative</td>
<td>[p]</td>
<td>palatalised voiceless labio-dental fricative</td>
</tr>
<tr>
<td>[v']</td>
<td>velarised voiced labio-dental fricative</td>
<td>[v]</td>
<td>palatalised voiced labio-dental fricative</td>
</tr>
<tr>
<td>[t']</td>
<td>velarised voiceless alveolar stop</td>
<td>[t]</td>
<td>palatalised voiceless alveolar stop</td>
</tr>
<tr>
<td>[d']</td>
<td>velarised voiced alveolar stop</td>
<td>[d]</td>
<td>palatalised voiced alveolar stop</td>
</tr>
<tr>
<td>[s']</td>
<td>velarised voiceless alveolar fricative</td>
<td>[s]</td>
<td>palatalised voiceless alveolar fricative</td>
</tr>
<tr>
<td>[ŋ']</td>
<td>velarised tense lamino-inter-dental nasal</td>
<td>[ŋ]</td>
<td>palatalised tense dorso-alveo-palatal nasal</td>
</tr>
<tr>
<td>[n']</td>
<td>velarised lax apico-alveolar nasal</td>
<td>[n]</td>
<td>palatalised lax apico-alveolar nasal</td>
</tr>
<tr>
<td>[ŋʰ']</td>
<td>velarised aspirated lax apico-alveolar nasal</td>
<td>[ŋʰ]</td>
<td>palatalised aspirated lax apico-alveolar nasal</td>
</tr>
<tr>
<td>[l']</td>
<td>velarised tense lamino-inter-dental lateral</td>
<td>[l']</td>
<td>palatalised tense dorso-alveo-palatal lateral</td>
</tr>
<tr>
<td>[ɿ']</td>
<td>velarised aspirated lax apico-alveolar lateral</td>
<td>[ɿ']</td>
<td>palatalised aspirated lax apico-alveolar lateral</td>
</tr>
<tr>
<td>[ɾʰ']</td>
<td>velarised alveolar long trill</td>
<td>[ɾʰ]</td>
<td>palatalised alveolar long trill</td>
</tr>
<tr>
<td>[ɾ']</td>
<td>velarised alveolar short trill</td>
<td>[ɾ']</td>
<td>palatalised alveolar short trill</td>
</tr>
<tr>
<td>[ɾʰ']</td>
<td>velarised aspirated alveolar short trill</td>
<td>[ɾʰ']</td>
<td>palatalised aspirated alveolar short trill</td>
</tr>
<tr>
<td>[ɾ']</td>
<td>velarised retroflex approximant</td>
<td>[ɾ']</td>
<td>palatalised retroflex approximant</td>
</tr>
<tr>
<td>[k']</td>
<td>velarised voiceless velar stop</td>
<td>[k']</td>
<td>palatalised voiceless pre-velar stop</td>
</tr>
<tr>
<td>[g']</td>
<td>velarised voiced velar stop</td>
<td>[g']</td>
<td>palatalised voiced pre-velar stop</td>
</tr>
<tr>
<td>[x]</td>
<td>voiceless velar fricative</td>
<td>[ç]</td>
<td>voiceless palatal fricative</td>
</tr>
<tr>
<td>[ŋ]</td>
<td>velar nasal</td>
<td>[ŋ']</td>
<td>palatalised pre-velar nasal</td>
</tr>
</tbody>
</table>

With few inaccuracies, the samples were thus idealized ‘Irish nonsense words’, with vowels involving a ternary height contrast and predictable front/back and lip-rounding qualities.

5.1.4.7.3 Construction of Stimuli

In many experiments on auditory perception, a speech synthesiser is used in order to record the stimuli. Unfortunately, a reliable synthesiser with the required features was unavailable, and manipulated real (human) speech was used in order to record the stimuli, in the following way:

- The speech samples were recorded in a completely quiet room, by the author, using his own voice, a microphone, and Praat software for recording, measuring (duration, pitch, amplitude and formants) and manipulating the samples.
- All samples started with the voiced alveolar plain stop [d] preceding the vowel.
- For each of the vowels [i e a o u], a common onset sample was recorded. This
sample was an initial chunk of a sample containing a CV sequence: the consonant [d] followed by the vowel, that is: [dɪ] [dɛ] [da] [dɑ] [dɔ] [dʊ]. The end of the common onset samples was always a point where the spectral rising amplitude was as a zero-crossing, right after the end of a voicing cycle (on the rise to a following voicing cycle), about 60ms after the release of the stop [d].

- All sequences of <vowel + postvocalic material> were recorded, with initial (prevocalic) [d] as well, e.g. [dɛm]. However, from each sample, only the end portion was used. The end portion is the chunk starting in a point where the rising amplitude was at a zero-crossing (on the rise to a new voicing cycle), about 50ms before the beginning of the postvocalic consonant.

- The stimuli were constructed by concatenating the common onsets to the end portions. Although formed by concatenated different speech samples, most of the stimuli sounded perfectly natural.

The following chart demonstrates graphically the construction of the stimulus [dɛm].

Figure 5.1: Illustration of the construction of the stimulus [dɛm]

![Diagram of stimulus construction](image)
5.1.4.8 Isolating parameters and neutralising external factors

The hypothesis to be tested in the experiments was that the *blurring effect* causes degraded vowel (vocalic height) recognition. Other external factors might enhance / weaken recognition as well, and they had to be minimised. I now explain how using the method outlined and other measurements managed to minimise these factors.

- **Background noises (blurred sample = poorer recognition).** As mentioned, the stimuli were recorded in a completely quiet (though not sound-proof) room, with no background noises.

- **Overall volume (louder sample = better recognition).** All common onsets and end portions used to construct the stimuli, for all vowels, had very similar amplitude during the vowel.\(^{65}\) The concatenation method guaranteed that all stimuli containing the same vowel had identical amplitude for a substantial portion of their duration.

- **Vowel duration (allegedly: longer vowel = better recognition).** The concatenation method guaranteed that vowel duration in each stimulus was almost identical (typically 105-115 ms).

- **Consistency of the fundamental frequency (variation in the fundamental frequency might result in auditory variation).** All common onsets and end portions used to construct the stimuli, for all vowels, had roughly the same fundamental frequency, about 120Hz. The concatenation method guaranteed that all stimuli containing the same vowel had identical fundamental frequency for a substantial portion of their duration. A pitch contour, which would arise as a result of the concatenation of a common onset with one fundamental frequency and an end portion with a different fundamental frequency, was not

\(^{65}\) or during the first vowel in bisyllabic stimuli.
audible for the vast majority of the stimuli, and the cases in which such a contour was audible were spread randomly across the corpus.

- **Consistency of articulatory gesture (inconsistency = variation in resonations = variation in auditory quality).** End portions for a given vowel were typically recorded consecutively, with care taken to maintain roughly the same articulatory gesture. The concatenation method guaranteed that all stimuli containing the same vowel had identical resonance for a substantial initial portion of their duration (common onset) while preserving acoustic alternations inflicted by the postvocalic material for a substantial final portion of their duration (end portion).

- **Consistency of prevocalic environment (inconsistency = irrelevant variation in the acoustic signal = irrelevant auditory variation).** All stimuli started with the same consonant, plain voiced [d], which is the most neutral consonant for vocalic transition (no aspiration, abrupt release, rather neutral tongue-dorsum position, neutral lip position). The concatenation method guaranteed that all stimuli containing the same vowel had an identical prevocalic environment.

- **Deterministic effect on auditory perception between consecutive stimuli (consecutive stimuli containing the same vowel are likely to result in biased transcription of the latter stimulus).** Consecutive stimuli never contained the same vowel.

5.1.4.9  The Role of the Perception Grammar

5.1.4.9.1  Non-neutralised Perception Grammar

One major external factor that had not been neutralised was the subjects’ perception grammar, that is, the processes that eventually map the physical excitation patterns
of the basilar membrane and auditory nerves through the various stages of auditory processing to the cognitive phonological vocalic categories. Phonetic transcription is done only after sound is perceived, that is, filtered by the perception grammar, and therefore reflects the pure cognitive mapping and not the excitation patterns or any intermediate stage.

Transcending one’s phonological perception grammar is probably one of the most difficult linguistic tasks, and though very skilled and experienced phoneticians can achieve a nearly neutral ear and transcribe auditory stimuli rather faithfully, this is definitely not the case with our subjects - first-year students of linguistics. Their only advantage over the normal population was their (rudimentary) experience in active phonetic transcription in general.

5.1.4.9.2 Perception Grammar and the Subjects’ Performance

All linguistic theories assume that the constituents of Grammar have, at least partially, judgement power, distinguishing (with various discrete or continuant degrees) the grammatical from the ungrammatical. There is no reason to assume that grammatical and ungrammatical utterances are processed similarly. Actually, it seems more likely that grammatical utterances undergo far more refined processing than ungrammatical utterances, because only grammatical utterances can be scanned for meaning.

Thus, if one stimulus is perceptually more grammatical than another, its recognition

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66 Notice the typical different behaviour in an environment of people speaking (a) one’s native tongue, where one can hardly ignore utterances, (b) one’s L2, where one typically switches on and off, (c) one’s Lm, where one typically tries to scan utterances to recognise some intelligible ones, until exhaustion and switching off, and (d) a totally foreign language, where one ignores almost everything. As for more specific vowel categorisation, the following is a good example: As an adolescent, with Hebrew as my native tongue ([i e a ɔ u]), and with exposure to typically Western European languages (including [y ø] languages), I used to spend some time listening to Turkish ([i e y ø u u u ɔ]) on the television. I had no problems recognising the vowels [i e a ɔ u], and only occasional problems recognising or distinguishing [y] and [ø], but only years later, during my introductory phonology classes in Tel-Aviv University, did I realise that many of the [e] (Hebrew’s default vowel) instances I had heard in Turkish were actually [u].
results might be better accordingly. I have to admit that during the construction and 
conducting of the experiments I was mostly unaware of this problem.

5.1.4.9.3 The Absence of Native Speakers of Irish among the Subjects

There were no native speakers of Irish among the subjects. In fact, this was probably 
desirable, since conducting the experiment with native speakers of Irish could only 
refute the details of the blurring effect hypothesis, but not confirm them: The 
perception grammar of Irish would militate against ill-formed utterances in Irish 
regardless of whether their ill-formedness was as a result of the blurring effect or 
some other reason. If supposedly blurred vowels are perceived like non-blurred 
vowels, then the perception grammar contains no bias against environments in which 
vowels are allegedly blurred, and it can be claimed that the blurring effect plays no 
role in the grammar. On the other hand, as the experiment tests the alleged 
manifestation of the blurring effect in Irish, significantly degraded recognition of 
supposedly blurred vowels confirms nothing except that these vowel instances are 
perceptually ungrammatical, a fact which is known about the language anyway, 
whatever the reason for this perceptual ungrammaticality may be67.

5.1.4.9.4 One Particular Perception Grammar: Hiberno-English

With the exception of 5 foreigners, all subjects were speakers of varieties of Hiberno-
English. Among them were about 5 subjects who happened also to be students of 
Irish, and perhaps up to 5 others who were diligent students of another foreign 
language and/or spent a substantial period of time in a non-English speaking country. 
However, the majority of had never had substantial exposure to any language other 
than English (though, living in Ireland, they probably had substantial exposure to 

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67 Of course, if the blurring effect does not play a role in the alternations in contemporary Irish, this 
discussion is irrelevant, because the grammar of Irish is like any other grammar in such case.
almost all major varieties of English)\textsuperscript{68}. Obviously, each subject’s transcriptions depended on the particular perception grammar of her own idiolect. However, with rather negligible inaccuracy, it is safe to assume an almost unified perception grammar, that of a hybrid variety of Hiberno-English dialects\textsuperscript{69}.

5.1.4.9.5 The Effects of Hiberno-English Perception Grammar

All the stimuli were nonsense words heard in isolation. I assume that, with minor inaccuracies, Peterson & Lehiste’s (1960) articulatory experiment on intrinsic durations of syllable nuclei in CVC (isolated) words in American English is quite representative. According to this experiment, testing both intrinsic vowel duration and the effect of the coda consonant on vowel duration, the \textit{shortest} vowel duration, typically of intrinsically short vowels [\textipa{ɪ ɛ u ʌ}] before a voiceless stop, was about 130-140ms\textsuperscript{70}. Given that in my experiment, vowel duration was always about 110ms, then, to the extent that vowel duration plays a role in vowel recognition and categorisation (Escudero&Boersma 2002), all vowels were probably ungrammatical. However, some vowels were definitely more grammatical than others. Thus, the vowels that are possibly intrinsically short [\textipa{ɪ ɛ u ʌ o ɔ}]\textsuperscript{71} are probably more

\textsuperscript{68} Although all the Irish subjects had been exposed to Irish through the school system, and some also used to attend Irish language summer colleges, they were unlikely to acquire Irish perception (or production) grammar, because of the lack of currency of Irish on a daily basis. Ní Chiosáin (personal communication), as well as others involved in the Irish speaking community outside the Gaeltachtai, claim that even the fluent Irish spoken by the majority of pupils in the Gaelscoileannaí (the Irish language medium schools outside the Gaeltachtai) has a hybrid grammar with a major English component, and clear English phonology.

\textsuperscript{69} As for each of the 5 foreign subjects, young adults whose native tongues differed from one another, with previous (typically British) English background and constant gradual adaptation to the Hiberno-English speaking environment in which they lived and studied, the perception grammar was definitely a hybrid of their native-tongues and a variety of English dialects. Tuning into the English constituent of their perception grammar was definitely more intensive during the experiments, as English was the only language used during all other parts of their phonetics sessions and university classes in general.

\textsuperscript{70} In their experiment, Escudero&Boersma(2002) measure much shorter durations. However, their sample words were embedded in a carrier sentence, and not uttered in isolation.

\textsuperscript{71} [\textipa{ɪ ɛ}] are intrinsically short in all varieties of English (\textit{bit, bet} respectively). [\textipa{o}] is intrinsically short in Hiberno-English (\textit{put, but}). [\textipa{ɔ}] is intrinsically short in many varieties of British English (\textit{pot}). [\textipa{ʌ ʌ}] are intrinsically short in British and American English (\textit{put, but} respectively).
grammatical than other vowels according to the subjects’ perception grammar. Additionally, in most varieties of English including Hiberno-English, the coda consonant affects the duration of the vocalic nucleus, as mentioned in section 2.5.3. For words uttered in isolation, 110ms duration of a vowel might be almost grammatical for a CVC word ending with a voiceless stop, but is far from grammatical for a word ending with a voiced fricative.

Finally, as English stressed monosyllables containing a short vowel must also contain a coda consonant, CV stimuli (with very short vowels) are also ungrammatical to some extent (but see section 5.2.1.4.1 the somewhat predictable but always very interesting solution that subjects typically resorted to for such stimuli).

**5.1.4.9.6 The Effect of Transcription Conventions**

Some subjects, like many speakers of Hiberno-English, are in the process of neutralising the contrast between /ə/ and /ʌ/, and say [o] for both, e.g. *look* and *luck* are homophonously [lok]. The fact that they neutralise the contrast does not imply that they are not familiar with the vowels [u] and [ʌ] – they hear these vowels whenever they are exposed to American or British English, and typically map both vowel qualities to the same vowel category, their native /o/.

However, the introduction to the task of phonetic transcription followed the American conventions of the transcription of English, which include the short vowels [u] and [ʌ], and ignore the short vowel [o]. During their phonetics lab sessions, the subjects were exposed to systematically contrastive [u] and [ʌ], but in their attempts to transcribe these two vowels correctly their success was significantly poorer than with other vowels. Thus, for example, for the English stimulus *must pull*, which is pronounced by these particular subjects as [mɒst pɔl], the probability that such a subject’s transcription
would be the ‘correct’ [mɔst ɒl] is relatively small, and the probability that the subject’s transcription would give the doubly-mistaken [mʌst pʌl], although smaller, is nevertheless very high, compared to other similar-but-different mistakes. It is clear that such a subject tends to map both [u] and [ʌ] stimuli to the same vowel category, and when she has to transcribe them, she knows that this vowel category is mapped onto two different vowel-symbols, but would not know which of the two to use.

Additionally, for such subjects, the short mid back rounded vowel, which never appeared in the recordings of the lab sessions but did appear in the experiment (transcribed as [ɔ] in this chapter), is typically mapped, together with short [u] and [ʌ], to the same vowel category. This bizarre situation is better demonstrated in the following chart:

<table>
<thead>
<tr>
<th>Auditory Quality</th>
<th>Grammatical Status</th>
<th>Phonemic Categorisation</th>
<th>Phonetic Transcription</th>
</tr>
</thead>
<tbody>
<tr>
<td>[u]</td>
<td>familiar (e.g. Brit. Eng.)</td>
<td>/o/</td>
<td>[u] and [ʌ] interchangeably</td>
</tr>
<tr>
<td>[ɔ]</td>
<td>similar to native (Hib. Eng. [o])</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[ʌ]</td>
<td>familiar (e.g. Brit. Eng.)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This discrepancy was doomed to recur in the experiments as well, and to introduce some statistical noise to the results of an experiment, which is based on the evaluation of the phonetic transcription of a vowel as correct or incorrect.

5.1.4.9.7 Why These Effects Are Marginal After All

First, although intrinsic duration, as well as contextual duration effects, are part of the subjects’ perception grammar, vowel quality per-se also plays a crucial role. Hence, at least to some extent, all short vowels can be perceived as instances of quality-identical intrinsically or contextually long vowels.

Second, the discrepancy between the transcription convention and the [u ʌ o] merger
was relevant only for some, but not all, of the subjects, and even these subjects were aware of this discrepancy\textsuperscript{72}.

Finally, and most importantly, whereas the effects of the perception grammar and transcription conventions are predicted to introduce some statistical ‘noise’, they bear no effect on the crucial questions to be answered. This is because apart from the distributional limitations on short vowels before $\ddagger$ in English, none of the effects mentioned can be attributed exclusively to \textit{sonorants}: Intrinsic duration and the convention discrepancy are a matter of the vowels themselves, and contextual duration distinguishes postvocalic voiceless stops (where the short duration is almost grammatical) from all other sorts of postvocalic material (where the short duration is ungrammatical), and the grammaticality/ungrammaticality contrast does not correspond to a contrast between postvocalic sonorants and postvocalic obstruents.

\textbf{5.1.4.10 Evaluation of Transcription}

\textbf{5.1.4.10.1 Evaluation according to vowel height only}

Ideally, evaluation of correct or incorrect recognition of vowel quality would probably be according to some scale of auditory distance. However, the auditory distance tested in this experiment was mono-dimensional, that of vowel height\textsuperscript{73}. For consistency in evaluation, incorrect front/back recognitions were ignored. Indeed, this was somewhat superficial, because the amount of auditory distance between the two precise vocalic qualities for each height varied from one height to another, with maximal distance for the pair $[\epsilon \ddagger]$, intermediate distance for the pair $[\ddagger \ddagger]$ and

\textsuperscript{72} During the lab-sessions they were told to pay particular attention to $[\ddagger \ddagger]$ difference, a difference they might not be aware of.

\textsuperscript{73} Imposing a scale of auditory distance between the target vowels represented by the IPA symbols used in the transcriptions and the vowels used in the stimuli is pure nonsense, as the subjects know nothing about auditory distances, and besides, by using an IPA symbol, the subject committed herself only to \textit{approximate} rather than \textit{precise} auditory vowel quality.
minimal distance for the pair [a α]. Hence, whereas it seems tolerable to ignore a front/back mistake for [a] and [α], it is equally intolerable to ignore a front/back mistake for [ɛ] and [ɔ]. However, front-back mistake-patterns within the same height obeyed the auditory distances mentioned, that is, front-back mistakes were very frequent for low vowels, occasional for high-vowels, and extremely rare for mid vowels. Therefore, ignoring all front-back mistakes doesn’t really change the overall picture, and is legitimate.

5.1.4.10.2 Vowel Height Evaluation of IPA Symbols

As the task was active transcription, that is, subjects used arbitrary IPA symbols and not specification of height values, evaluation had to include categorisation of IPA vowels into height degrees.

From their phonetics classes, the subjects were familiar only with a subset of the IPA vowel symbols, used for transcription of English: [i i e e æ a α ɔ ɔ ʊ u ʊ ø ø]. For the purpose of the experiment they were instructed never to use [ɔ] or [ʊ] (though they did use them occasionally). The other 12 vowel symbols were categorised as follows:

- High vowels: [i i u u]
- Mid vowels:[e e ø ø]
- Low vowels: [æ a α α]

Any of the four vowel symbols within a height category was evaluated as correct recognition for a target vowel of the same category, and any of the other symbols, including [ɔ] and [ʊ], were evaluated as incorrect.

However, there were two systematic exceptions:

- As a combination of the effects of intrinsic vowel duration and convention

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The vowel [ʌ] was included among the low vowels because, in the stimuli, (a) the back mid vowel [ɔ] was pure mid (not a lower mid), with clear lip rounding, and (b) the low vowel [α], being centralised, was ‘higher low’ and ‘fronted back’ and clearly unrounded, making it sound precisely between, say, American [ʌ] and American [α]. However, notice the systematic evaluation exceptions mentioned.
discrepancy, many transcription forms included very rare or even no instances of the symbols [o] and [œ], but did display systematic distinction between the use of [ʌ]-transcriptions and [a]-transcriptions, typically with [ʌ]-transcriptions corresponding to [ɔ]-stimuli and [a]-transcriptions corresponding to [ɑ] stimuli. In such forms, all instances of [ʌ] were evaluated as ‘mid vowel’. However, such instances of [ʌ] were never evaluated as ‘mid vowel’ if the stimulus contained the mid front vowel [ɛ].

- As a direct effect of intrinsic vowel duration, many transcription forms included very rare or even no instances of the symbols [a] and [æ]. Very few of such forms, however, displayed a systematic distinction between [ɛ]-transcriptions and [e]-transcriptions, with [ɛ]-transcriptions corresponding to [a]-stimuli and [e]-transcriptions corresponding to [ɛ]-stimuli. In these forms, all instances of [ɛ] were evaluated as ‘low vowel’. However, these instances of [ɛ] were never evaluated as ‘low vowel’ if the stimulus contained the low back vowel [ɑ].

5.1.4.11 Hind-Sight

Given the very intensive task of active transcription, and the evaluation problems that evolved, a method of passive (multiple choice) transcription would probably have been better. By using passive transcription I could have forced the subjects to use more vowel-quality cues than duration cues. For example, given a very short mid [ɔ], and multiple-choice involving [a e u ɔ], I would have forced subjects to map a short vowel to indicate the nearest (and most easily interpretable) intrinsically long vowel category. Both the subjects’ task and the evaluation procedure would have been easier, but statistically significant tendencies would have been similarly apparent.
5.2 The Experiments

5.2.1 Comparison between simple-coda environments

5.2.1.1 Hypothesis
This experiment was conducted in order to check whether vowel-height recognition is indeed affected by different coda consonants, and to verify whether the most fundamental hypothesis about the blurring effect in Irish has some empirical grounding, that is, do the sonorants [m n l r ŋ] form significantly blurring codas, compared to other consonants?

5.2.1.2 Description
This experiment tested subjects’ recognition of vowel height for the six vowels [ɪ ē a α ō u] before 20 different postvocalic materials, namely the neutral material (no coda) and 19 simple codas: [p b f v m t d s n n l l r ř k g x ň].

The three lax coronal sonorants [n l r] were, as they are in those dialects of Irish that maintain a lax/tense contrast, shorter than their equivalents in most other languages. Their durations were about half the duration of their tense counterparts, which were longer than their equivalents in most other languages (and in the case of [N] and [L] also involving marked tongue positions).

The 120 stimuli (6 vowels * 20 environments) were divided to two groups of 60 stimuli each, the first group containing stimuli with the vowels [ɪ ē a] and the second containing stimuli with the vowels [ē α ō u]. The experiment was carried out over two sessions. The first session examined recognition of the first group of stimuli, and the second examined recognition of the second group.

As mentioned in section 5.2.8.7, consecutive stimuli never had the same vowel. As for the postvocalic material, the stimuli were more or less in random order.

31 Subjects participated in both sessions, giving 31 transcriptions for each stimulus,
and 186 (6*31) transcriptions for each of the postvocalic materials.

5.2.1.3 Results

The following table displays the recognition results for this experiment. The top row lists the 20 codas, ordered from left to right according to total sum of vowel recognition (bottom row). The leftmost column lists the 6 vowels, as well as sub-total sums for non-high vowels and high vowels, and total sums. Each cell contains the number of correct vowel-height recognition of one particular stimulus, whose vowel and postvocalic material can be detected by the row and the column respectively.

Table 5.3: Recognition results for stimuli containing simple coda environments

<table>
<thead>
<tr>
<th></th>
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<th>k</th>
<th>v</th>
<th>f</th>
<th>p</th>
<th>b</th>
<th>f</th>
<th>r</th>
<th>L</th>
<th>N</th>
<th>m</th>
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<td>a</td>
<td>30</td>
<td>24</td>
<td>25</td>
<td>22</td>
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<td>26</td>
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<td>A</td>
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<td>128</td>
<td>125</td>
<td>125</td>
<td>123</td>
<td>123</td>
<td>120</td>
</tr>
</tbody>
</table>

The following figure summarises these results in percentages of correct recognition for high and non-high vowels separately, across coda consonants.

Figure 5.2: Correct recognition (%) for high/non-high vowels across coda consonants
5.2.1.4 Discussion

5.2.1.4.1 Intuitive Observations

The following tendencies are easily detectable from these results:

- Recognition results for high vowels are very good and more or less consistent for all following consonantal environments (always above 80%, see figure 5.2), with no significant variability, and definitely without categorical variability dependent on the features of the coda consonant.

- For non-high vowels, the results show a clear tendency: Except for the lax coronal sonorants [l] and [n], (and given the unclear status of with the velar nasal [ŋ]), a postvocalic sonorant degrades vowel-height recognition. Within the sonorants, rhotics in particular seem to degrade recognition more.

- Within coronal sonorants, including rhotics, recognition of vowel height is clearly better before lax sonorants (short and with unmarked tongue position) than before tense sonorants (long and with marked tongue position).

- There are possible tendencies towards better vowel-height recognition before voiceless obstruents, and towards worse recognition before labials. Recall that the subjects’ perception grammar, which plausibly rules out very short vowels in an open syllable as well as before voiced fricatives, sonorants, voiced stops and voiceless fricatives, might be responsible for the first tendency (though voiceless fricatives seem to be a clear exception here).

- The role of the perception grammar is clearly apparent in the transcription of no-coda stimuli: Not only are their recognition results rather mediocre, an interesting fact which is not apparent in the chart is the widespread tendency of subjects to pad their transcriptions for these stimuli with imaginary final [t].
5.2.1.4.2 Statistical Analysis

One should be cautious with a simple statistical analysis of the data, because of additional parameters resulting from the perception grammar, and the variability of recognition and/or transcription skills among the subjects. Still, I would like to present the following statistical analysis:

Let us assume that subjects have identical recognition and transcription skills (this is rather legitimate as in reality more-skilled subjects counterbalance less-skilled ones). For simplification, let us further assume that all stimuli are equally ungrammatical according to the perception grammar. Thus, the neutral (no-coda) environment can serve as a reference environment whose recognition results reflect standard performance of vowel-height recognition of our subjects.

For non-high vowels, binomial probability of correct recognition is then:

\[
\frac{89}{124} = 0.718. \text{ Hence: } n = 124, y = 89, p = 0.718, q = 0.282.
\]

Given all these, it is possible now to calculate standard deviation, according to the normal approximation formula (Oakes 1998:4):

\[
\sigma = \sqrt{p*q*n} = \sqrt{0.718*0.282*124} = \sqrt{25.107} = 5.01. \text{ Thus: } \sigma = 5.01
\]

The null-hypothesis (see Oakes 1998:9 for definition) is that the blurring effect does not exist, and that the recognition results for all sorts of postvocalic material are results in normal distribution.

Following accepted norms in many fields of science let us posit the following thresholds for deviation from normal distribution:

- Restrictive threshold (normal distribution probability < 10\%): \( z = -1.29\sigma = -6.46 \)
  \( th_{10} = 89 - 6.46 = 82.54 \). According to \( th_{10} \), all postvocalic material with 82 or less correct height recognitions of non-high vowels, are not in normal distribution.

- Moderate threshold (NDP < 5\%): \( z = -1.64\sigma = -8.22 \)
  \( th_5 = 89 - 8.22 = 80.78 \)
• Permissive threshold (NDP < 1%): $z = -2.32\sigma = -11.62$. $\text{th}_1 = 89 - 11.62 = 78.38$

Looking again at the subtotals for non-high vowels, it is apparent that all obstruents, as well as the lax [n] and [l], are all above the various thresholds. Among all sonorants except for lax [n] and [l], the velar nasal [ŋ] is between thresholds, and the rest are even way below the permissive threshold:

Table 5.4: Significantly degraded recognition of pre-sonorant non-high vowels

<table>
<thead>
<tr>
<th>t</th>
<th>x</th>
<th>s</th>
<th>l</th>
<th>g</th>
<th>d</th>
<th>n</th>
<th>k</th>
<th>f</th>
<th>p</th>
<th>v</th>
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</tr>
</thead>
<tbody>
<tr>
<td>102</td>
<td>99</td>
<td>98</td>
<td>94</td>
<td>92</td>
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<td>72</td>
<td>70</td>
<td>68</td>
<td>68</td>
<td>66</td>
</tr>
</tbody>
</table>

It seems, therefore, that the null hypothesis has to be rejected, and that the hypothesis checked in this experiment has been validated.

Similar analysis for recognition of all vowels presents a very similar picture:

$n = 186, \mu = 144, p = 0.774, q = 0.226, \sigma = \sqrt{(0.774*0.226*186)} = 5.705$

• Restrictive threshold: $\text{th}_{10} = 144 - 1.29*5.705 = 136.64$

• Moderate threshold: $\text{th}_5 = 144 - 1.64*5.705 = 134.65$

• Permissive threshold: $\text{th}_1 = 144 - 2.32*5.705 = 130.76$

Table 5.5: Significantly degraded recognition of pre-sonorant vowels

<table>
<thead>
<tr>
<th>t</th>
<th>s</th>
<th>x</th>
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<td>156</td>
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<td>125</td>
<td>125</td>
<td>123</td>
<td>123</td>
<td>120</td>
</tr>
</tbody>
</table>

It is worthwhile noting that these calculations are based on the assumption that the effect of the perception grammar is negligible. If we take into account that our reference environment is somewhat ungrammatical, so that our calculations are valid only for ungrammatical environments (all environments except for voiceless stop in coda), we can even explain why there is extreme (non-normal) deviation towards better recognition in the case of final [t]. However, according to the very same perception grammar, if the blurring effect were pure fiction, the results for a [v]-coda
should have been worse than the results for each and every sonorant-coda.

5.2.1.5 Conclusion

Both intuitive interpretation and statistical analysis of the results of this experiment seem to confirm the hypothesis that all postvocalic non-lax sonorants degrade vowel-recognition, or in other words blur vowel quality. Among sonorants, rhotics seem to be particularly blurring, and even lax [r] seems to have a clear blurring effect.

With regard to the perceptual superiority of high vowels compared to non-high vowels as the results seem to imply, there might be a few factors involved:

- High vowels are shorter than non-high vowels in languages in general and in English in particular. Thus, given the fact that vowel duration was maintained roughly identical across all stimuli with vowel qualities, the ungrammaticality of the over-short high vowels used in the experiment is smaller than the ungrammaticality of the over-short non-high vowels. As ungrammaticality seems to degrade perception, the perception of high vowels is less degraded than the perception of non-high vowels, and their recognition results are better.

- The over-shortness of all vowels creates a perceptual bias towards the recognition of a given vowel as high. To the extent that vowel duration plays a role in recognition, then if short duration is a cue for a high vowel, all vowels contain a cue for a high vowel. If such a bias were indeed dominant, it would have been predicted that high vowels would be correctly recognised almost 100% of the time, and that vowel-height recognition mistakes would result in false recognition of a non-high vowel as high, but not in false recognition of a high-vowel as non-high. The fact that the very good recognition performance of high-vowels was still at the level of less than 90%, that is, more than 10% of the high vowels were not perceived as such, implies that such a bias was
not too strong, though it might nevertheless be present.

- High vowels are not only shorter, but also quieter, than non-high vowels, that is, their intensity is lesser. In the experiment, however, vowel intensity was similar for all stimuli with all vowel qualities. As the auditory image of a sound depends on its intensity, the equal intensities of high and non-high vowels imply a relatively clearer auditory image for high-vowels than for non-high vowels, compared to normal speech conditions, where their intensities are not equal. Notice, however, that in high vowel stimuli, the intensity of the coda consonant is also louder, so its backward masking potential is greater.

- Finally, it might be the case that high vowels are rather immune to blurring, due to their ‘relatively stable acoustic property … that yields a relatively well-defined type of response in the auditory system’ (Stevens 1998:268), which is attributed to the centre of gravity effect, that is, the merger of the fundamental frequency and the first formant to a single auditory prominence (see section 2.3.2.4).

5.2.1.6 Hind-Sight
This experiment provides clear support for my hypothesis concerning the role of the blurring effect in Irish, but to some extent, I missed the opportunity to make a generalisation over all sonorants, because the ‘lax’ short [n] and [l] seem not to be blurring. I hope to repeat a similar experiment in the future, but to divide it into two separate experiments, one comparing normally articulated sonorants and obstruents, and the other comparing various durations and manners of sonorants only.
Also, it seems that somehow an experiment on vowel perception should maintain duration and intensity ratios between vowel qualities, rather than equalise these acoustic properties, because the equalisation seems to result in perceptual bias towards the amplified vowel qualities (typically higher vowels) and against the
shortened vowel qualities (typically lower vowels).

5.2.2 Tauto- vs. Hetero-/Ambi-syllabic Postvocalic Sonorant.

5.2.2.1 Hypothesis
This experiment was conducted in order to test the hypothesis that the *blurring effect* of postvocalic sonorants depends on syllabic position. More precisely, the purpose was to verify whether, as was hypothesised in section 2.3.3 and as seemed to be the case in Irish, tauto-syllabicity of the sonorant enhances *blurring* (and degrades recognition).\(^{75}\)

5.2.2.2 Description
This experiment tested subjects’ recognition of vowel height for the 6 vowels [i e a ɔ ɔ u], in 10 environments. The environments were the 5 non-lax sonorants [m n l r ɾ], either in coda position (tauto-syllabic with the preceding vowel) or in onset position (followed by a schwa-like vowel, and hetero-/ambi-syllabic with the preceding vowel). The intervocalic sonorants were slightly shorter than the coda sonorants, but involving a roughly identical gesture. The overall prominence of the postvocalic material was larger in the case of the intervocalic sonorants, which were followed by a roughly 100ms-long schwa-like vowel. Thus, if syllabification does not play a role in backward masking in particular and in *blurring* in general, *blurring* should be greater in the case of hetero-/ambi-syllabic intervocalic sonorants.

The experiment contained 60 stimuli (6 vowels * 5 sonorants * 2 syllabic positions), and was carried out in one session.

31 Subjects participated in the session, giving 31 transcriptions for each stimulus, and 186 (6*31) transcriptions for each environment.

\(^{75}\) The status of intervocalic consonants following a stressed short vowel in English, vis-à-vis the preceding vowel, is usually ambi-syllabic rather than hetero-syllabic, but in any case not tauto-syllabic of course.
5.2.2.3 Results

The following table displays the recognition results for this experiment. The top row lists the 10 environments, as well as general tauto-syllabic and hetero-/ambi-syllabic following sonorant.

The leftmost column lists the 6 vowels, as well as sub-total sums for non-high vowels and high vowels, and total sums. Each cell contains the number of correct vowel-height recognitions for one particular stimulus, whose vowel and postvocalic material can be detected by the row and the column respectively.

Table 5.6: Recognition results for stimuli containing variably syllabified postvocalic sonorant

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<th>_Ca</th>
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<td>93</td>
<td>102</td>
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<td>562</td>
</tr>
</tbody>
</table>

The following figure summarises these results in percentages of correct recognition for high and non-high vowels separately, across different postvocalic materials.

Figure 5.3: Correct recognition (%) for high and non-high vowels before variably syllabified sonorants
5.2.2.4 Discussion

5.2.2.4.1 Intuitive Observations

The following tendencies are easily detectable from these results:

• Again we can see that the height recognition rate for high vowels is again very high, for all postvocalic consonants, both in tauto-syllabic and hetero-syllabic position. Accordingly, there seems to be no influence of syllabic position of the postvocalic consonant. This is definitely the case for [u], whereas for [i] there seems to be a slight tendency towards better vowel-height recognition with a following tauto-syllabic sonorant. Still, the over all recognition rates are very high (similar to the rates in the previous experiment, for both sonorant and obstruent coda) and the difference is mainly due to the results for one pair of stimuli, namely [d̪m̩] (31 correct recognitions = 100%) versus [d̪m̪o̱] (23 correct recognitions = 74%). Therefore, it is equally likely that the apparent tendency mentioned for [i] is actually a random result.

• For non-high vowels, where recognition rates are not as high, the tendency is clear: Recognition is better when the following sonorant is in hetero-/ambi-syllabic position. This is evident both from the percentage of correct recognitions of vowels preceding all tauto- versus hetero-/ambi-syllabic sonorants (44.4% vs. 54% respectively), and from the percentages of correct recognitions for the two syllabic positions for each and every sonorant. Out of the 20 tauto- vs. hetero-/ambi-syllabic stimuli pairs, 13 had better recognition results for the hetero-/ambi-syllabic sonorants, 5 had better results for the tauto-syllabic sonorants, and 2 had equal results. Such a distribution is not to be expected if both environments have an equal effect on perception (or no
effect at all). However, considerations of the perception-grammar cast certain doubts, as will be explained below.

- Height recognition for non-high vowels is far weaker than in the previous experiment. It is somewhat unsafe to compare the two experiments because they were not carried out with exactly the same subjects, and subject variability may cause differences in the overall results between two experiments. However, subject variability holds true for the two different sessions of the previous experiment as well, and still the results there were more or less similar. I suggest that the reason for the overall weakened height recognition for non-high vowels, in this experiment, is directly related to the blurring effect, that is, to the nature of the stimuli in this experiment. In contrast with the previous experiment, in this experiment all stimuli contained a postvocalic sonorant, that is, an allegedly blurring environment. Therefore, if the blurring effect is real, all (or at least most) stimuli containing non-high vowels were perception-challenges, involving a relatively difficult and somewhat tedious recognition process, with possible distracting and/or exhausting effects on the subjects. However, the relatively laborious nature of the task is not manifested in a gradual degradation in recognition performance of later stimuli, and the overall weaker results are spread throughout all stimuli containing non-high vowels, earlier ones and later ones alike.

- Recognition of the vowels [a] and [ɔ] is significantly weaker than the rest of the vowels. This was not at all apparent in the previous experiment. I believe that this fact is directly related to the role of the perception grammar (and transcription conventions). Recall that if a Hiberno-English perception grammar relies on vowel duration as an important cue for vowel categorisation, then
short vowels are somewhat unlikely to be mapped to a vocalic category that would be transcribed by [a æ o ɔ], which correspond only to inherently-long vowels in English. Stimuli of short [a] and [ɔ] before a sonorant might be ruled out as instances of [a] and [ɔ] categories by the perception grammar, whereas stimuli of short [i ɛ ə u] can be perceived, by the same grammar, as instances of [i ɛ ə u] categories which are available in English as short vowels. As both articulatory (gesture) and acoustic (formant values) characteristics of the vowels in the [a] and [ɔ] stimuli had been prototypical, it is hard to think of any other explanation for this. That this tendency was not at all apparent in the previous experiment (even for blurring sonorants) might indicate, again, that the current experiment was more exhausting, causing subjects to resort to their perception grammar and tune their ‘beginning-phonetician ear’ off.

5.2.2.4.2 Statistical Analysis

Unlike the previous experiment, in this experiment we cannot identify a neutral environment whose results can be treated as representative of vowel-height recognition in general.

However, if we still assume that height recognition probabilities for non-high vowels are more or less consistent across subjects, vowels, and all pre-sonorant environments, then we can do the following:

• Regard all transcriptions of a given stimulus as a set of 31 members of binomial distribution. As such, the number of correct recognitions (or average recognition rate) for each stimulus is a member of a population of numbers in the range 0-31 in normal distribution (because a sum of 30 or more positive occurrences of binomial events is a number that behaves in
normal distribution).

- Treat the numbers of correct recognitions of each pair of tauto- vs. hetero-/ambi-syllabic sonorant stimuli (e.g. correct recognitions of [dɛm̩]) vs. correct recognitions of [dɛm]) as a **matched pair**.

- Construct the **null hypothesis**, that hetero-/ambi-syllabic and tauto-syllabic postvocalic sonorants are **equally blurring**.

- Perform a **one-tailed matched pairs t-test** (Oakes 1998:15-16) over the 20 matched pairs of the non-high vowels, with 19 (N-1) degrees of freedom:

**Table 5.7: Data for matched pair t-test for recognition of vowels before variably syllabified sonorants**

<table>
<thead>
<tr>
<th>Pair</th>
<th>tauto-syllabic</th>
<th>hetero-/ambi-syllabic</th>
<th>d</th>
<th>d²</th>
<th>Pair</th>
<th>tauto-syllabic</th>
<th>hetero-/ambi-syllabic</th>
<th>d</th>
<th>d²</th>
</tr>
</thead>
<tbody>
<tr>
<td>ðɛ̃m̩</td>
<td>19</td>
<td>20</td>
<td>-1</td>
<td>1</td>
<td>ðɛ̃m̩</td>
<td>18</td>
<td>21</td>
<td>-3</td>
<td>9</td>
</tr>
<tr>
<td>ðɛ̃r̩</td>
<td>13</td>
<td>20</td>
<td>-7</td>
<td>49</td>
<td>ðɛ̃r̩</td>
<td>11</td>
<td>19</td>
<td>-8</td>
<td>64</td>
</tr>
<tr>
<td>ðɛ̃ŋ̩</td>
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<td>22</td>
<td>-1</td>
<td>1</td>
<td>ðɛ̃ŋ̩</td>
<td>11</td>
<td>16</td>
<td>-5</td>
<td>25</td>
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<tr>
<td>ðɛ̃m̩</td>
<td>19</td>
<td>23</td>
<td>-4</td>
<td>16</td>
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<td>17</td>
<td>20</td>
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<td>4</td>
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<td>14</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ðɛ̃r̩</td>
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<td>13</td>
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<td>1</td>
<td>ðɛ̃r̩</td>
<td>9</td>
<td>16</td>
<td>-7</td>
<td>49</td>
</tr>
<tr>
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<td>7</td>
<td>0</td>
<td>0</td>
<td>ðɛ̃t̩</td>
<td>7</td>
<td>5</td>
<td>2</td>
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<tr>
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<td>17</td>
<td>-4</td>
<td>16</td>
<td>ðɛ̃g̩</td>
<td>9</td>
<td>20</td>
<td>-11</td>
<td>121</td>
</tr>
<tr>
<td>ðɛ̃m̩</td>
<td>14</td>
<td>9</td>
<td>5</td>
<td>25</td>
<td>ðɛ̃m̩</td>
<td>11</td>
<td>19</td>
<td>-8</td>
<td>64</td>
</tr>
<tr>
<td>ðɛ̃r̩</td>
<td>10</td>
<td>19</td>
<td>-9</td>
<td>81</td>
<td>ðɛ̃r̩</td>
<td>17</td>
<td>17</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Thus: \(\sum d = -62; \sum d^2 = 540; N = 20\)

The formula: \(t = \frac{\sum d}{\sqrt{((N*\sum d^2-(\sum d)^2)/(N-1))}}\).

Therefore:

\(t = -62 / \sqrt{(20*540-(-62)^2)/19) = -62 / \sqrt{(10800-3844)/19}) = -62 / \sqrt{366.1} = -3.241\)

With 19 degrees of freedom, the null hypothesis should be discarded with 99.5% certainty if the t-score exceeds ±2.861 (Oakes 1998:260). As the t-score indeed exceeds this threshold, it is safe to discard the null hypothesis, despite some
inaccuracies in the assumptions.

Height-recognition for non-high vowels is thus **significantly better** when the following sonorant is hetero-/ambi-syllabic.

### 5.2.2.5 An Important Word of Caution

According to Lehiste (1970:40) the duration of a sound in general and of a vowel in particular is influenced by the total number of sounds and syllables in the word, and the greater the number of sounds and syllables, the shorter the sounds are. The current experiment compared \([\text{CVC}]\) utterances to \([\text{CVCV}]\) utterances. If such normal speech utterances are compared, the durations of the sounds in a \([\text{CVC}]\) utterance would typically be longer than the duration of the corresponding sounds in a \([\text{CVCV}]\) utterance, because the ratios between the number of sounds is 3:4, and between the number of syllables is 1:2.\(^\text{76}\)

If these facts are reflected in the Hiberno-English perception grammar, and there is no reason to assume they are not, then comparing vowel recognition of CVC-stimuli and CVCV-stimuli is useless if vowel durations are identical. The same short vowel, which might be grammatical in a CVCV stimulus, could be ungrammatical in a parallel CVC stimulus. Whereas the results in this experiment are unambiguously significant, they might be directly reflecting grammaticality judgements of the perception grammar, rather than a difference between a strong and a moderate blurring effect.

### 5.2.2.6 Conclusion

Both intuitive interpretation and statistical analysis of the results of this experiment

---

\(^\text{76}\) For example, in the recordings reported in Escudero & Boersma (2002:3), vowels in \([\text{CVC}]\) words are significantly longer than the first vowels in \([\text{CVCV}]\) in English. Lehiste (1970:40) provides similar data from Hungarian.
confirm the hypothesis that the *blurring effect* of sonorants is position-dependent, and that *blurring* is enhanced (and vowel-height recognition weakened) if the sonorant is in a tauto-syllabic coda position. Some uncertainty and caution should be maintained, however, due to a possible role of the perception grammar in disfavouring over-short vowels only before coda-consonants (in monosyllables). If such a role exists, difference in subjects’ performance might be reflecting differences in grammatical status rather than the effect of the syllabic position of the *blurring* sonorant.

Additionally, the overall very low recognition results for non-high vowels, compared to their far higher recognition results in the previous experiment, seem to support the *blurring effect* hypothesis: The task in this experiment seems to have been perceptually exhausting, but the only difference between the two experiments, which may have resulted in exhaustion in the current experiment but not in the former experiment, is that in this experiment all stimuli contained postvocalic, allegedly *blurring*, sonorants.

### 5.2.3 The Blurring Effect and Vowel Duration

#### 5.2.3.1 Hypothesis

This experiment was conducted in order to validate the somewhat trivial assumption that vowel length indeed plays a role in vowel recognition, that is, that height recognition is better for longer vowels.

#### 5.2.3.2 Description

It was rather evident from the preceding experiments that the recognition of high vowels is unaffected by a following sonorant. Therefore they were not included in the current experiment. However, subjects were not informed about this fact, in order to allow false recognitions of vowels as high. This experiment tested height recognition for the remaining four non-high vowels [ɛ a ɔ ɔ̃], and the environments were tauto-
syllabic sonorants [m n l r ŋ ŋ].

For each vowel, another common onset was made. It was identical to the other common onset in the sense that it was taken from the same master sample, but it contained 4 more voicing cycles (about 30ms). For each vowel-sonorant pair two stimuli were made, one with the longer onset portion, and an overall vowel duration of about 140ms, and one with the shorter onset portion, and an overall vowel duration of about 110ms (as in the previous experiments).

The experiment contained 48 stimuli (4 vowels * 2 lengths * 6 sonorants), and was carried out in one session.

27 subjects participated in this experiment, giving 27 transcriptions for each stimulus and 108 (4*27) transcriptions for each combination of vowel duration + sonorant.

5.2.3.3 Results

The following chart displays the recognition results for this experiment. The top row lists the 6 different postvocalic material. The leftmost column lists the 8 vowels (4 qualities * 2 lengths), as well as the subtotals for short vowels and long vowels in general. Each cell contains the number of correct vowel-height recognitions of one particular stimulus, whose vowel and postvocalic material can be detected by the row and the column respectively.

<table>
<thead>
<tr>
<th></th>
<th>_m</th>
<th>_n</th>
<th>_l</th>
<th>_r</th>
<th>_r:</th>
<th>_ŋ</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>2</td>
<td>6</td>
<td>6</td>
<td>32</td>
</tr>
<tr>
<td>a'</td>
<td>8</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>11</td>
<td>41</td>
</tr>
<tr>
<td>á</td>
<td>16</td>
<td>15</td>
<td>19</td>
<td>9</td>
<td>12</td>
<td>16</td>
<td>87</td>
</tr>
<tr>
<td>á'</td>
<td>19</td>
<td>17</td>
<td>20</td>
<td>19</td>
<td>15</td>
<td>20</td>
<td>110</td>
</tr>
<tr>
<td>ɛ</td>
<td>14</td>
<td>7</td>
<td>17</td>
<td>18</td>
<td>16</td>
<td>13</td>
<td>85</td>
</tr>
<tr>
<td>ɛ'</td>
<td>22</td>
<td>12</td>
<td>24</td>
<td>18</td>
<td>16</td>
<td>19</td>
<td>111</td>
</tr>
<tr>
<td>ë</td>
<td>11</td>
<td>9</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td>52</td>
</tr>
<tr>
<td>ë'</td>
<td>12</td>
<td>14</td>
<td>11</td>
<td>10</td>
<td>8</td>
<td>11</td>
<td>66</td>
</tr>
<tr>
<td>short v.</td>
<td>45</td>
<td>37</td>
<td>52</td>
<td>35</td>
<td>40</td>
<td>47</td>
<td>256</td>
</tr>
<tr>
<td>long v.</td>
<td>61</td>
<td>51</td>
<td>60</td>
<td>51</td>
<td>44</td>
<td>61</td>
<td>328</td>
</tr>
</tbody>
</table>
The following figure summarises these results in percentages of correct recognition for short and long vowels, across the various postvocalic sonorants:

**Figure 5.4: Correct recognition (%) for short and long vowels across postvocalic sonorants**

5.2.3.4 Discussion

5.2.3.4.1 Intuitive Observations

The results should be interpreted straightforwardly: Lengthening enhances recognition. In 19 of the 24 short/long vowel pairs, recognition results were better for the longer member, and only in 3 were the results better for the shorter member (2 pairs had identical results for both members).

Notice that the recognition ratio between short and long vowel is almost identical across vowel qualities:

\[
\begin{align*}
[a]: & \frac{32}{41} = 0.7805; \\
[\alpha]: & \frac{87}{110} = 0.7909; \\
[\epsilon]: & \frac{85}{111} = 0.7658; \\
[\text{o}]: & \frac{52}{66} = 0.7879; \\
\text{All vowels}: & \frac{256}{328} = 0.7805
\end{align*}
\]

Interestingly, the duration ratio between short and long vowels is almost identical (110/140 = 0.7857). One is tempted to suspect a linear correlation between vowel duration and vowel recognition, as if crucial auditory cues for vowel height accumulate linearly as vowel articulation progresses, at least along this range of durations. I leave this issue for future research.
Height recognition for the vowels [a] and [ɔ] was again very poor, even below random recognition rate of 54 (27 transcriptions * 6 environments / 3 heights). Still, if it were the case of any random statistical noise, the short/long recognition ratio would have been severely affected. That this is not the case definitely indicates that the results for [a] and [ɔ] are still reliable.

Again, the perception grammar might be playing a role in these results: Superficially speaking, if the postulated grammatical-duration boundary for short vowels before a sonorant coda is beyond 110ms, and at the vicinity of 140ms, it might play a role in weakening recognition of the shorter vowels. In such a case differences in recognition levels reflects also grammatical status and not necessarily duration effects.

5.2.3.4.2 Statistical Analysis

Since in this experiment we again compare two environments (two different vowel durations) across pairs, with no presumed reference recognition rates, the appropriate device is the one-tailed matched pairs t-test.

Our null hypothesis is that duration plays no role in recognition.

Following are the 24 matched pairs:

Table 5.9: Data for matched pairs t-test of long vs. short vowels

<table>
<thead>
<tr>
<th>Pair</th>
<th>short v.</th>
<th>long v.</th>
<th>d</th>
<th>d²</th>
<th>Pair</th>
<th>short v.</th>
<th>long v.</th>
<th>d</th>
<th>d²</th>
</tr>
</thead>
<tbody>
<tr>
<td>.det̩ 1</td>
<td>17</td>
<td>24</td>
<td>-7</td>
<td>49</td>
<td>dar̩ 4</td>
<td>19</td>
<td>20</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>dér̩ 1</td>
<td>18</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>dar̩ 3</td>
<td>9</td>
<td>19</td>
<td>-10</td>
<td>100</td>
</tr>
<tr>
<td>dér̩ 1</td>
<td>16</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>dər̩ 1:</td>
<td>12</td>
<td>15</td>
<td>-3</td>
<td>9</td>
</tr>
<tr>
<td>dər̩ 1</td>
<td>7</td>
<td>12</td>
<td>-5</td>
<td>25</td>
<td>dər̩ 1:</td>
<td>15</td>
<td>17</td>
<td>-2</td>
<td>4</td>
</tr>
<tr>
<td>dəm̩ 1</td>
<td>14</td>
<td>22</td>
<td>-8</td>
<td>64</td>
<td>dam̩ 1</td>
<td>16</td>
<td>19</td>
<td>-3</td>
<td>9</td>
</tr>
<tr>
<td>dər̩ 1</td>
<td>13</td>
<td>19</td>
<td>-6</td>
<td>36</td>
<td>dər̩ 1</td>
<td>16</td>
<td>20</td>
<td>-4</td>
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<td>3</td>
<td>9</td>
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<td>11</td>
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<tr>
<td>dəl̩ 1</td>
<td>2</td>
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<td>-2</td>
<td>4</td>
<td>dəl̩ 1:</td>
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<td>5</td>
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<td>8</td>
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<td>25</td>
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<td>1</td>
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<td>25</td>
<td>dəl̩ 1:</td>
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<td>11</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

160
Thus: $\sum d = -72; \sum d^2 = 428; N = 24$

Therefore:

$$t = \frac{-72}{\sqrt{(24 \times 428 - (-72)^2)/23}} = \frac{-72}{\sqrt{221.2}} = -4.842$$

The t-score exceeds the ±2.807 boundaries of 99.5% certainty for 23 degrees of freedom (Oakes 1998:260), so the null-hypothesis can safely be discarded.

5.2.3.5 Conclusion

Both intuitive interpretation and statistical analysis of the results of this experiment strongly confirm the hypothesis that correct vowel-height recognition is in positive relation to vowel duration.

Because of a possible role of the perception grammar, caution should be maintained, as always. However, previous studies on sound perception have established that longer duration enhances perception and immunity to masking (see section 2.3.2.4 and references therein). Therefore, the hypothesis is rather trivial, and as the results are so consistent, it is probably safe to state that the hypothesis is confirmed.

5.2.4 Additional Experiments

Apart from the experiments reported above, additional experiments were carried out. These experiments were intended to test specific alleged manifestations of the blurring effect hypothesis in Irish, one related to the pre-cluster lengthening and epenthesis alternations, and the other to the final devoicing alternations. The hypotheses were as follows:

- Recognition of a vowel preceding a sonorant-initial cluster is facilitated if the second element in the cluster is a voiceless stop.

- Recognition of a pre-sonorant vowel is facilitated if the sonorant is devoiced.

In order to test the first hypothesis, [dVCCV] stimuli were used. Stimulus
construction was similar to the construction in previous experiments, and the stimuli contained real clusters. However, the sonorant portions in these clusters were not controlled for duration, intensity and voicing, across stimuli. Thus there was great variability in the acoustic properties of the postvocalic sonorants across stimuli. Recognition results for these stimuli had no significant implications, and as the stimuli were rather unreliable, the whole experimental setting had to be discarded.

In order to test the second hypothesis, sonorant-final [dVC] stimuli were used, containing both fully voiced final sonorants and devoiced final sonorants. It turned out later, however, that as intensity control was not used for the postvocalic sonorant, in some cases the intensity of a final devoiced sonorant was greater than the intensity of the corresponding fully voiced sonorant, due to strong aspiration. For most pairs of stimuli contrasting only in the voiced vs. devoiced nature of the postvocalic sonorant, vowel recognition was better when the intensity of the sonorant was smaller, regardless of whether it was the voiced or the devoiced sonorant. These encouraging results should nevertheless be discarded due to the lack of intensity control. When a new version of this experiment was carried out, with consistent intensity differences between devoiced and voiced sonorants, recognition results seemed to confirm the hypothesis: recognition of vowels before devoiced [rʰ] was 10% better than before voiced [r], and recognition of vowels before devoiced [lʰ] was 20% better than before voiced [l]. However, as stimuli for nasals were not included in this experiment, a generalisation about all sonorants cannot be made, and as the overall number of stimuli was small (16), these encouraging results should serve as a basis for a more comprehensive experiment.

5.3 Summary of the Experiments
The first three experiments reported seem to have confirmed the following
hypotheses:

- Postvocalic sonorants exert a *blurring effect* over the preceding vowels.

- The longer the sonorant, the stronger the *blurring effect*, a fact that is directly related to the backward masking component of the *blurring effect* (the target-to-masker ratio is lesser).

- The *blurring effect* is stronger when the postvocalic sonorant is tauto-syllabic with the vowel than when it is hetero-syllabic or ambi-syllabic with regard to the preceding vowel.

- The *blurring effect* is stronger when the vowel is shorter, a fact that is probably related both to the co-articulatory colouring effect (the shorter the vowel, the more substantial the coloured portion is), and to the backward masking effect (the target-to-masker ratio is greater).

Additionally, the later experiments seem to support the hypothesis that the *blurring effect* is weaker when the postvocalic sonorant is devoiced. However, this hypothesis has yet to be confirmed by a more carefully designed experiment.

5.4 Prospective Experiments

While concluding of this thesis, I am preparing for a new series of experiments, which are more carefully designed. These experiments will include the following modifications:

- Forced choice experiments: the task will involve forced multiple choice of possible transcriptions for each stimuli. The forced choice task will reduce side effects such as exhaustion, slips of the pen and diversion of the subjects’ attention from the vowel, and will hopefully minimise the effect of the transcription convention discrepancy.

- Global, rather than Irish-oriented, attitude: the task will involve schwa-
coloured, rather than palatalised or velarised consonants, in order to neutralise the effects of perceptually ungrammatical sounds and of postvocalic preconsonantal off-glides, that might affect vowel perception. Co-articulatory cues for vowel quality are nevertheless neutralised by using consonants excised from schwa vocalic environments, with one voicing cycle of schwa preceding the consonant.

- Better isolation of variables: with pitch and intensity manipulation, there will be no effects of unnatural pitch and intensity contours. Moreover, backward masking and auditory colouring will be separated. In the experiment on backward masking, the whole vowel will be taken from the same sample, concatenated to the single voicing cycle of schwa preceding the consonant. In the experiment on co-articulatory colouring, the postvocalic sonorant will be taken from the same sample, and different portions of a co-articulatory coloured vowel will replace the later voicing cycles of the vowel. Consonant duration will be kept similar for all consonants in all experiments, except for an experiment testing the effect of consonant duration.

- More natural duration and intensity ratios across vowel qualities: in order to reduce the bias favouring high vowels and disfavouring low vowels, vowel duration and intensity will be different across height categories. Durations will be 80ms for high vowels, 87ms for mid vowels, and 94ms for low vowels. Vowel intensities will first be equalised to an arbitrary schwa intensity (with which all consonant intensities are in natural ratios), and then the low vowels will be slightly amplified and the high vowels slightly attenuated, to intensity levels which will again be in natural ratios with the following sonorants (mid vowels remain with the equalised intensity).
With these modifications, I hope to get results which are reliable, thus enabling the statement of conclusions with a high degree of confidence.
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