Universidad de Deusto
Deustuko Unibertsitatea

The Gradient Nature of Hiatus Resolution in Spanish

PhD dissertation by

Irene Barberia Aurrekoetxea

Directors:

Carolina González (Florida State University)

Jon Andoni Franco (University of Deusto)

Bilbao, 2012

ABSTRACT

This dissertation investigates hiatus resolution of non-high vowels in Spanish, under the effect of five phonological contexts: vowel position and quality, word boundaries, word type, syllable type and coda type. The main purpose is to gain knowledge about the gradient nature of hiatus resolution in this language, which resolves via different strategies at the phonetic output, namely acoustic diphthongization, gliding, coalescence or deletion. Hiatus resolution is a phonetic process in Spanish, totally optional and speaker dependent. In order to resolve hiatus, a durational reduction of the vowel sequence is required. This is claimed to be motivated by the five phonological factors at study, some which are revealed to be more relevant than others. Previous studies dealing with vowel sequences in Spanish focus on the phonological hiatus/diphthong alternation of such vowel sequences (Harris 1983, Roca 1997). But more recent studies based on phonetic data show intermediate stages of realizations between phonological hiatus and diphthong (Aguilar 1999, 2003; Hualde 2004, Hualde & Chitoran 2003), suggesting a continuum of processes, which has led to a number of unresolved questions on the subject, some of which are addressed in this work.

The core of this dissertation consists of a double experiment involving a production task and a lexical decision task. The double experiment offers two major contributions to the literature on hiatus resolution in Spanish. First, it provides us with clear instances of the different strategies used by Spanish speakers to resolve hiatus. A description is proposed of four strategies that conform to the gradient nature of hiatus resolution in Spanish through the analysis of acoustic data: acoustic diphthongization, gliding, coalescence and deletion. Durational variation of the vowel sequence at the phonetic output is the main criterion used for the classification of those strategies. Linked to that, a binary division of the strategies is also proposed, which is determined by the existence of two vocalic segments (in hiatus, acoustic diphthongization and gliding) versus a single vocalic segment (in coalescence and deletion). Secondly, the results of the experiment help us understand in depth the relevance of the segmental and

prosodic factors that contribute to the phenomenon of hiatus resolution. The findings show that the interaction of vowel position and quality has an effect on hiatus resolution, since durational reduction of the vowel sequences has a direct influence on the quality of the vocalic segments involved, in terms of perception of the vowels; and, added to that, the choice of the strategy of hiatus resolution is dependent on the context in which both vowels appear in the sequence (V1 or V2 position). Word boundaries and word type also affect hiatus resolution. Indeed, hiatus resolution strategies are often applied in vowel sequences across word boundaries, but within the word limits, the speaker prefers to maintain the canonical distribution of the vowels. Furthermore, in contexts across word boundaries, hiatus resolution seems to affect vowel sequences in function+content word combinations the least. In turn, vowel sequences in content+content and content+function word combinations allow hiatus resolution more often. Finally, the results demonstrated that codaless sequences resolve hiatus less often than sequences with a coda. Among the various coda groups in the language, obstruent codas, with the exception of the apico-alveolar sibilant, block hiatus resolution more often than sonorant codas. The apico-alveolar sibilant /s/ coda shows a radically different behavior, since it does not block hiatus resolution. Moreover, it allows deletion more often than any other coda groups. This fact confirms the special status of this consonant within the phonological consonantal system of the language.

The analysis on vowel sequences in contact within the research framework of this dissertation has a theoretical import since hiatus resolution involves discrete phonological categories that appear in constant relation with gradient phonetic parameters, shared among speakers in real time. Phonology is primarily the study of a categorical system with a specific structure and based on lexical contrasts, shared among speakers. Phonetics, in turn, describes gradient phenomena of production and perception in real time which are speaker dependant. However, it is arresting to note that hiatus resolution shows an interaction of both disciplines. Crucially, this dissertation provides data that support an integrated approach to Phonetics and Phonology.

ACKNOWLEDGEMENTS

It has definitely been during the long writing process of this work that I have truly understood this is not one person's project, but a team job. This dissertation is the result of the work of a number of people, even if I got to put it into words in the pages you are about to read.

Two people have been instrumental in the development of this dissertation. I am indebted to my directors, Carolina González and Jon Franco; even if I know whatever I write in these lines will never be enough to express my gratitude to them. Professor González has been of great help in my formation as a phonologist-phonetician, keeping a close eye on my development as a researcher in the field and continuously encouraging me to keep up with the research work. Professor Franco has complemented that education showing me tenacity, practicality; pushing me into further investigations by teaching me to question myself and my work. He has been of invaluable help and an exemplary mentor throughout these years of my academic and professional development. The constant support of professors González and Franco, their effort and trust throughout these years have made this dissertation a reality. I owe it to them.

I would also like to express my gratitude to José Ignacio Hualde, who sponsored me during my stay at University of Illinois at Urbana-Champaign (UIUC). He helped me carry out the phonetic experiment that has later become the core of this dissertation. His sponsorship also allowed me to participate in the academic life at the Linguistics department at UIUC: I am thankful to Jennifer Cole, for letting me sit at her classes and participate in a number of phonology discussions; also to the *Praat* Script group (Jessica Miller, Lisa Pierce, Alicia Burga, Cecilia Ovesdotter Alm, Miquel Simonet and Francisco Torreira). Simonet and Torreira, together with Marisol Garrido (another graduate student at UIUC) have also developed an interest in vowel sequences and hiatus resolution and their published work has taken a relevant place in this dissertation.

Thanks are also due to Michael Leeser, from Florida State University (FSU), for his help on a number of questions that arose while doing the statistics in this dissertation. He was always encouraging and willing to spend some of his invaluable time whenever I knocked on his door. I would like to thank him mostly for his support. Thanks to Robert Cameron too, who shared his experience on developing a PhD dissertation and encouraged me to finish as soon as possible the long hours that analyzing data took me in the lab. Carolina González (my co-director), Michael and Robert allowed me to join the FSU staff for one semester. By doing so, I have been able to find the time I was lacking to write as much as I could, to be in contact with other professionals in the field and enjoy academic life at a maximum.

A special mention is a must for those who, directly or indirectly, arose in me the interest in Phonology and Phonetics and motivated me to pursue further studies in the field: Mario Saltarelli, Jean Roger Vergnaud, Rachel Walker and Dani Byrd form the University of Southern California; Jon Ortiz de Urbina and Alex Iribar from the University of Deusto.

Last, but not least, I thank the audiences at NAPhC4, ISCA Workshop 2006 and 15th MFM for a number of comments and suggestions that motivated partly the development of this project at different stages.

*   *   *   *   *

This dissertation is dedicated to my friends and family, especially my parents, Imanol and Marije, and my brother Imanol; they have offered me, above all, the necessary emotional support that was decisive throughout these past years. I am also grateful to Javi, my husband, who pushed me to finish it when I needed it the most: thank you for your patience, your positive attitude and your encouragement (we both learnt from it, didn´t we!).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The following dissertation is a study of the effects of a number of segmental and prosodic factors on hiatus resolution in Spanish. It aims at shedding some light on its gradient nature, from a phonetic and a phonological perspective.

The term *hiatus resolution* refers to the various strategies that languages use in order to avoid two adjacent heterosyllabic vowels (i.e. *hiatus*) at the phonetic output. This can be explained by the crosslinguistic preference for CVCV syllables. From the point of view of production, it has been claimed that such strategies are used in languages that disprefer CVCV syllables, as it is the case for Spanish (Baković 2006, Chitoran & Hualde 2007). It has also been claimed that speakers apply hiatus resolution strategies in a gradient manner, basing their choice of the strategy on patterns of prosodic lengthening (Simonet 2005). From a perception point of view, the avoidance of adjacent vowels is motivated by a perceptual reduction of vowel distinctions in weak contexts, which triggers changes in the vowels, in order to neutralize (or at least *reduce*) those distinctions (Sands 2004). Such reductions of vowel distinctions are not limited to contexts of adjacent vowels, however. Unstressed syllables, for instance, force a change in quality (to schwa, for example) of vocalic segments in many languages, including English, French and many others (Crosswhite 1999).

The terms *reduction* or *reduced vowel* are widely used in the literature in a number of ways in the context of vowel neutralization and hiatus resolution. Acoustically, reduction refers to the centralization and decrease in duration of a vowel (Fourakis 1991). The term is also used for one of the strategies of hiatus resolution, namely, *vowel reduction*: one of the vowels in a heterosyllabic sequence becomes shorter and loses some of its acoustic cues, becoming monosyllabified (Aguilar 2003). Such reduction does not necessarily involve centralization. Throughout this dissertation, the term *reduction* is adopted to refer to durational reduction only[1]; another term, *diphthongization*, is used to refer to the strategy that previous literature names vowel reduction.

The core of this dissertation consists of a double experiment involving a production task and a lexical decision task performed by eight native speakers of Peninsular Spanish, in order to study the effects of a number of factors on vowel sequences in hiatus contexts in Spanish. The factors that the study focuses on are: (i) position of the vowel in the vowel sequence and vowel quality, (ii) word boundaries, (iii) word type, (iv) syllable type and (v) coda type. The main goal is to obtain empirical information that contributes to understand the gradient nature of the various strategies that resolve hiatus, based on phonological foundations. Most of previous studies dealing with vowel sequences in Spanish focus on the hiatus/diphthong alternation of such vowel sequences. But more recent studies based on phonetic data show intermediate stages of realizations between phonological hiatus and diphthong, proposing a continuum of processes, which has led to a number of unresolved questions on the subject.

This dissertation supports previous literature (Aguilar 1999, 2003; Hualde 2004, Hualde & Chitoran 2007) that claims a gradient nature of hiatus resolution strategies. A proposal of four different strategies is made: diphthongization, gliding, deletion and coalescence. (1) *Diphthongization* occurs where durational reduction of one of the vowels in the sequence causes monosyllabification, without changing the quality of the vowels in the sequence. (2) *Gliding* involves a qualitative change in the vowel sequence, occurring when the hiatus sequence results in a vowel and a glide. Both diphthongization and gliding involve monosyllabification of the vowel sequence; for both, one of the vowels in the sequence must undergo durational reduction. A step further in the hiatus resolution continuum involves a durational reduction of the sequence into a single vowel: this is caused through deletion or coalescence. (3) *Deletion*, on one hand, refers to a strategy where one of the vowels in the sequence is not pronounced. On the other hand, when (4) *coalescence* applies, the only vowel that appears in the output combines characteristics of both hiatus vowels. Duration of a

[1] However, throughout chapter 1 (only), which provides a description of previous literature on the topic, the term *reduction* is borrowed from various sources to refer to one of the strategies of hiatus resolution, involving decreased duration and loss of acoustic features of the vowel, à la Aguilar (2003).

single vowel is appreciated and reduction also applies in this case: F1 corresponds to one vowel, while F2 belongs to the other vowel[2].

Evidence of these strategies is provided by the data obtained in the double experiment. The production experiment aims at capturing instances of the various strategies that resolve hiatus. Subjects carried out a reading task where the sentences included words and word pairs with various vowel sequences. The effect on the production of the vowel sequences of the segmental and prosodic factors focus of the study was then recorded by means of acoustic measurements of duration and formant frequency. A subsequent categorization of these produced vowel sequences was made into the strategies of hiatus resolution. The lexical decision experiment focuses only on the strategy of deletion, considering deletion as the most radical strategy of hiatus resolution. Subjects were asked to listen to words and word pairs containing only one of the vowels where hiatus should appear. Subjects then judged those sound inputs as correct or incorrect Spanish. The goal of this task is to gain knowledge on the intuitions of speakers towards deletion, under the effect of the factors that were the focus of the investigation.

The answer that this dissertation seeks to reveal is twofold. First, to what extent the strategies of hiatus resolution can be predicted in certain context, given that the adequate factors that affect resolution in such context take place. Second, to what extent we can expect phonological cues (and what phonological cues) to be crucial in these strategies. The purpose is first to describe the strategies that conform the gradient nature of hiatus resolution in Spanish through the analysis of acoustic data. Secondly, the study will aim at defining the roles of both phonetics and phonology in the continuum of the strategies that the language uses to resolve hiatus, as well as describing the interrelation between both. Thus, the double experiment offers two major contributions to the literature on hiatus resolution in Spanish. First, it provides us with clear instances of the different strategies used by Spanish speakers to resolve hiatus. Secondly, the results of the experiment help us understand in depth the relevance of segmental and prosodic factors that contribute to the phenomenon of hiatus resolution.

Durational reduction is the determinant factor for hiatus resolution to happen. Hiatus resolution is a phonetic process, totally optional and speaker dependant. In order

---

[2] Chapter 2 provides further details and examples of these strategies.

to apply any of the strategies to resolve it, a durational reduction of the vowel sequence is required. This is claimed to be motivated by different phonological factors, some which are revealed to be more relevant than others.

This dissertation focuses on the study of non-high vowel sequences, which are assumed to be in hiatus before the lexical level (Núñez Cedeño & Morales-Front, 1999). Hiatus resolution in Spanish occurs in contexts where there is durational variability (Aguilar 2003). Durationally impoverished contexts, such as faster speech rate or unstressed syllabic positions, may create poorer perception; thus, either we speed up articulatory movements to reach the target articulators or we minimize articulatory effort by reducing the vowel space, then, a crowded vowel space leads to misperception and to loss of contrast between vowels (Barnes 2002 and Flemming 2005).

There are emerging studies (c.f. Simonet 2005, Garrido 2008) dealing with the topic of co-articulation and vowels contact, and this dissertation aims at contributing partly to this literature, by focusing on the interaction of non-high vowel sequences in eight different contexts selected according to the results of previous literature. The effect of the factors acting in those contexts is registered through the double experiment. It is assumed that hiatus resolution in Spanish is a phonetic phenomenon and speaker dependant (even intra-speaker dependant). However, under the effect of the factors above, strategies that resolve hiatus seem to apply with certain systematicity across speakers, or at least there is certain consensus among native speakers. To what extent do these strategies occur systematically? Can they be predicted? Finding answers to these questions can shed light on the phonologization process that certain vowel sequences have undergone. Furthermore, focusing on the effects of vowel quality on hiatus resolution strategies complements previous literature and contributes to the understanding of the interaction between perception and production cues in speech.

This dissertation is divided into 5 chapters, which are organized as follows. Chapter 1 sets the bases for this dissertation. It introduces phonological vowels in Spanish (section 1.1) and moves on to describe the behavior of those vowels in contact (section 1.2). Due to the different behavior of vowels when high vowels appear in the vowel sequences, a special section is dedicated to those sequences containing high vocoids (section 1.3). The rest of the dissertation is consecrated to non-high vowel sequences. Section 1.4 provides a review of the main literature dealing with hiatus resolution in Spanish, specifying the factors that have been proposed to affect it as well as the strategies that Spanish uses to avoid hiatus. A final section in the chapter (section 1.5) focuses on the idea that hiatus resolution in Spanish operates in a gradient manner, rather than defining hiatus resolution strategies in a categorical way. This idea is supported by the fact that hiatus resolution in Spanish is a phonetic process, which supports an interaction of phonetics and phonological units in it.

Chapters 2 and 3 present a phonetic study of vowel sequences, designed to capture instances of hiatus resolution in Spanish in various contexts. Chapter 2 describes the methodology and procedures to develop that experiment (sections 2.1 and 2.2 respectively). Section 2.1 defines the various segmental and prosodic factors which shape up the contexts that affect hiatus resolution and section 2.2 proposes a definition of the different strategies that conform to the gradient process of hiatus resolution, based on the experimental procedures. The results of the experiment are reported in chapter 3, through the analysis on the data of durational variations of the vowels (section 3.2), the actual occurrence of the various strategies of hiatus resolution (section 3.3) and through the description of the vowels that change their nature when hiatus resolution takes place (section 3.4). A summary of the significant results is provided in the last section (section 3.5).

Chapter 4 describes the design and results of a lexical decision experiment on vowel sequences undergone deletion, one of the strategies of hiatus resolution. This experiment complements the survey on production described in chapters 2 and 3 by focusing on native speakers' intuitions about a specific strategy to avoid hiatus in Spanish. Section 4.1 reviews the bases of the experimental design, maintaining the model of the corpus from the production experiment in chapter 2. Section 4.2 describes the methodology and the development of the lexical decision task. Section 4.3 reports the results, which contribute to confirm some of the general proposal in the previous chapter. Section 4.4 wraps up the overall results.

Chapter 5 concludes this work providing a review of the general results from the double experiment as a whole and an analysis of the data (section 5.1), summarizing the significant findings and stating how they contribute to the field (section 5.2); and finally, developing a discussion with concluding remarks, which prompt a number of questions that need further investigation and are left for future research (section 5.3).

CHAPTER 1

THE BEHAVIOR OF VOWEL SEQUENCES IN SPANISH

1.1. Characteristics of phonological vowels in Spanish

One way to classify vowels in Spanish is according to the position of the tongue body and the shape of the lips: in a vertical dimension high vowels /i, u/, mid vowels /e, o/ and low vowel /a/; in the horizontal dimension, front vowels /i, e/, central /a/ and back vowels /o, u/. Back vowels also have lip rounding; backness and rounding in Spanish are two features that go together, contributing to enlarge the oral cavity when producing those sounds (Hualde 2005). Figure 1 below illustrates the phonemic vowel chart in Spanish.

Figure 1
Phonemic vowels of Spanish

	Front	Central	Back
High	i		u
Mid	e		o
Low		a	

These vowels have a range of phonetic realizations, which occur in terms of advancement and height. This variation seems to be contextually determined. For instance, mid vowels /e, o/ show a *closed* pronunciation, i.e. with a greater closure of the oral cavity before palatal consonants, and an *open* pronunciation, i.e. with a greater openness of the oral cavity in contact with a trill or before a /x/ (Hualde 2005: 122; Navarro Tomás, 1990). According to Navarro Tomás (1990), low vowel /a/ shows four pronunciations: central [a], usually produced in stressed syllables in Spanish, a *palatalized* variant, a *velarized* variant and a *relaxed* form in rapid familiar speech. Vowels /i, u/ show three pronunciations like mid vowels, *closed*, *open* and *relaxed*, as well as two more variants each: they may appear as *semivowels* following a mid or a low vowel, or as *semiconsonants* preceding a mid or a low vowel, which are known as glides. Glides in Spanish are assumed to be allophonic variations of high vowels (Hualde 2005:54), non-syllabic counterparts of the vowels in specific contexts. More on high vowel/glide alternation is discussed in section 1.3.

The above descriptions make direct reference to adjacent sounds of the vowels, which influence their qualitative realization. It also makes an indirect reference to the position of the vowels in the sequence (whether they are in the first or second position in the vowel sequence, henceforth V1 or V2 positions). Both of these factors (adjacent consonants and position of the vowel in the sequence) have an effect on the realization of the underlying vowels in the sequence. However, they are not the only factors and the literature provides numerous studies that contribute to the description of the quality of the vowels, without a consensus. For a review of the different phonetic realizations of Spanish vowels refer to, among others, Navarro Tomás (1990), Alarcos Llorach (1974) Monroy (1980), Borzone de Manrique (1980), D'Introno et al. (1995), Aguilar (1997) and Veiga (2002).

The lack of agreement on a systematic description of the phonetic variation of vowels (c.f. Aguilar 1997) is partly due to the realization of vowels in vowel sequences (VV-sequences). There are 25 possible combinations of VV-sequences in the language. Table 1 below exemplifies them within and across word boundaries.

Table 1
VV-sequences within and across word boundaries

VOWELS	WITHIN WORD BOUNDARIES		ACROSS WORD BOUNDARIES	
/ii/	*nihilismo*	‘nihilism’	*mi idea*	‘my idea’
/iu/	*ciudad*	‘city’	*vi una*	‘(I) saw one’
/ie/	*sociedad*	‘society’	*mi esposo*	‘my husband’
/io/	*silencio*	‘silence’	*mi opinión*	‘my opinion’
/ia/	*media*	‘half’	*mi amigo*	‘my friend’
/uu/	---	---	*tu universidad*	‘your university’
/ui/	*cuidar*	‘to look after’	*su imagen*	‘his image’
/ue/	*juego*	‘game’	*tu esposa*	‘your wife’
/uo/	*antiguo*	‘old, ancient’	*tu orgullo*	‘your pride’
/ua/	*agua*	‘water’	*su alteza*	‘your majesty’
/ee/	*creer*	‘to believe’	*entre ellos*	‘between them’
/ei/	*peine*	‘comb’	*me importa*	‘it matters (to me)’
/eu/	*europeo*	‘European’	*tiene una*	‘(he) has one’
/eo/	*empleo*	‘employment’	*te odia*	‘(he) hates you’
/ea/	*realismo*	‘realism’	*este año*	‘this year’
/oo/	*alcohol*	‘alcohol’	*como otros*	‘like others’
/oi/	*oído*	‘ear’	*no importa*	‘(it) doesn’t matter’
/ou/	*estadounidense*	‘(pers. from USA)’	*sólo uno*	‘only one’
/oe/	*poesía*	‘poem’	*como él*	‘like him’
/oa/	*toalla*	‘towel’	*cinco años*	‘five years’
/aa/	*Saavedra*	‘(last name)’	*hacia atrás*	‘backwards’
/ai/	*bailar*	‘to dance’	*tema importante*	‘important topic’
/au/	*autor*	‘author’	*la universidad*	‘the university’
/ae/	*aeropuerto*	‘airport’	*la escuela*	‘the school’
/ao/	*bacalao*	‘cod-fish’	*una opinión*	‘an opinion’

The phonetic outputs of the items in table 1 vary notably. Spanish allows sequences of two or three vowels within a syllable (diphthongs or triphthongs, respectively). In such contexts, the requirement of having a single vowel as sonority peak in the syllable may lead the other vowel(s) to undergo qualitative changes. The focus in this dissertation is, partly, on the study of the variations of those vowels in VV-sequences that do not act as sonority peaks. When adjacent vowels belong to different syllables, each vowel is a sonority peak in their own syllables. Even in those contexts, they may suffer qualitative changes and undergo resyllabification under certain conditions of durational reduction.

1.2. The behavior of vowel sequences

1.2.1. Identical vowel sequences

The number of words containing identical vowel sequences in Spanish is relatively low, inexistent in the case of /uu/ sequences within word boundaries. Within word boundaries, they are usually orthographically separated by an epenthetic *h* (except in borrowings), as in *azahar* 'orange blossom', *alcohol* 'alcohol', unless they appear at morphemic boundaries such as in verb forms (*creer* 'to believe', *leer* 'to read' and others), or prefixed words (reeditar 'to re-edit', portaaviones 'aircraft carrier', etc.). The phonetic realization of these sequences in heterosyllabic position (that is, [V1.V2]) is rare, and they seem to merge into a single vocalic segment: /V1.V2/ → [V]. Aguilar (2003) notices, however, a durational distinction between a single vowel and a single vocalic segment resulting from merging two identical vowels: two homorganic vowels are longer than a single vowel, but shorter than the added duration of two vowels.

There is a number of words whose lexical distinction is made through the vowel sequence. They are orthographically distinguished, but their phonetic realization may lead to confusion. Words such as the previously mentioned *azahar* and *azar* 'chance' may both be realized as [a.ˈθar]. Disambiguation can be achieved through contextual information, but also through a durational distinction of the vowel sequence: in the first example duration of the vowel sequence is longer than in the second one. Thus, Spanish does make a distinction between a single vowel and a sequence of two homorganic vowels in terms of duration (Aguilar 2003). Two homorganic vowels have a greater duration than a single vowel, against the traditional belief that two homorganic vowels systematically reduce to one during the speech act. Stress also plays a part in the duration of the vowels. Usually, stressed vowels are longer than unstressed ones (Monroy 1980).

1.2.2. Non-identical vowel sequences: hiatus/diphthong contrast

Phonologically, sequences of non-high vowels within word boundaries are heterosyllabified, as in *teatro* ‘theater’ ([te.ˈa.tɾo]). But when a high vowel is involved, then (i) either the high vowel bears stress and hiatus takes place, as in *teoría ‘theory’* ([te.o.ˈɾi.a]) or (ii) the high vowel is unstressed and diphthongization occurs, as in *peinar* ‘to comb’ ([pej.ˈnaɾ]). Across word boundaries, vowel sequences are presumably heterosyllabified, regardless of vowel height or stress, due to word boundaries. The phonetic realizations of non-identical vowel sequences differ, however, from the phonological structures, dependent on varieties, speakers and style within a single speaker, which seem to favor hiatus resolution. Across word boundaries, a word sequence such as *este asunto* (‘this subject’) may be pronounced in hiatus as [es.te#a.ˈsun.to], but also with vowel reduction as [ˈes.te̯#a.ˈsun.to][3], diphthongization as [ˈes.tja.ˈsun.to] or else [ˈes.ta.ˈsun.to]. The choice of one phonetic realization or another is due to the durational reduction in the actual phonetic realization, as a result of factors such as loudness and pitch variation (Barrutia & Schwegler, 1994).

Within word boundaries, Spanish has phonological diphthongs. These are made up of two high vowels or a high vowel plus a mid or a low vowel. Within the lexical word, vowel sequences must contain at least a high vowel. The examples in (1) show common cases of diphthongs in Spanish.

(1)	a. *hay*	[ˈaj]	‘there is’
	b. *causa*	[ˈkaw.sa]	‘cause’
	c. *piano*	[ˈpja.no]	‘piano’
	d. *cuando*	[ˈkwan.do]	‘when’
	e. *cuida*	[ˈkwi.ða]	‘he takes care’
	f. *ciudad*	[θju.ˈðað]	‘city’

[3] The symbol [̯] for non-syllabicity is used to mark the reduction of the vowel.

Examples (1a) through (1d) show diphthongs of a high vowel plus a non-high vowel; examples (1e) and (1f) show cases of diphthongs formed by two high vowels. All of these examples can also show realizations of the vowel sequences in hiatus. These realizations are marked and obey to certain factors that limit their production to specific contexts, as we will see below.

When both vowels are non-high, each vowel belongs to a different syllable phonologically, as in examples like *poeta* ([po.ˈe.ta] ‘poet’). However, for examples in (1), there are various phonetic realizations in certain contexts of fast speech: the vowel sequence merges into a single syllable, leading to pronunciations such as [ˈpo̯e.ta]. Furthermore, in certain contexts of familiar speech diphthongization takes place, and the first vowel becomes a glide ([ˈpwe.ta]). Other examples of this change are illustrated in (2) next:

(2)	a. *Bilbao*	[bil.'βa.o]	‘(name of city)’	→	[bil.'βaw]
	b. *aldeano*	[al.de.'a.no]	‘peasant’	→	[al.'dja.no]

One of the reasons for such changes is linked to the syllabic structure of the word itself: a syllable without an onset is dispreferred in Spanish, so resyllabification of the onsetless vowel into the previous one resolves having an onsetless syllable (Colina 2009). However, this does not explain the hiatus tendency in the examples in (1). This dissertation aims at pinning down the influencing factors for such cases (also, refer to section 1.3). Additionally, when a vowel sequence appears in initial position, as in *huevo* ([ˈwe.βo] ‘egg’), it may also undergo fortition; as a consequence, the first segment in the sequences strengthens ([ˈgwe.βo]).

Spanish allows sequences of three consecutive vowels i.e. triphthongs. Within a syllable, the first and last vowels are high and the central one a non-high. Consider the next examples:

(3)	a. apreciáis	[a.pre.ˈθjajs]	‘you (pl.) appreciate’
	b. averiguáis	[a.βe.ɾi.ˈɣwajs]	‘you (pl.) find out’

Unlike in the case of diphthong, there are no triphthongs exclusively made up of high vowels i.e. *[jij], *[wuj] or any other combinations. Other examples include compound words such as *semiautomático* ([se.mjaw.to.ˈma.ti.ko] 'semiautomatic'), or regional pronunciations of words ending in /-a.δo/, which become [-aw] such as *desgraciado* ([des.gra.ˈθjaw] 'miserable'). The number of triphthongs in Spanish is much lower than that of diphthongs. However, both triphthongs and diphthongs are very common, especially when we consider vowel sequences across word boundaries.

In connected speech vowel sequences may resyllabify regardless of their nature. Diphthongs and triphthongs occur to avoid adjacent heterosyllabic vowels during the speech act. Speakers of Spanish use a number of strategies to avoid heterosyllabic vowels in connected speech. Two factors have been identified as contributors to this reduction process to a single syllable: stress and word boundaries. Syllables in weak positions such as unstressed syllables tend to undergo reduction more often than syllables in strong positions. Vocalic sequences across word boundaries reinforce that tendency in connected speech. The effects of stress and word boundaries, among other factors, are further discussed in chapter 2.

1.3. Variation and high vowel resyllabification

The starting point of this dissertation is the well known debate in the linguistic literature of Spanish on the phonological status of high vowels [i,u] versus glides [j,w]: the phonological description on vowel syllabification in Spanish defines vowel sequences in heterosyllabic positions if they are non-high vowels or if the high vowel in the sequence bears stress. But when the high vowel is unstressed, the sequence merges into one syllable; diphthongization takes place and the high vowel becomes a glide (Hualde 2005). This is illustrated through examples in (4). Example (4a) shows two non-high vowels, which are phonologically distributed into different syllables; the same occurs when the high vowel in the sequence bears stress, as in (4b). But when the high vowel is unstressed, then diphthongization must occur, as in (4c).

(4)	a. cohete	[ko.ˈe.te]	‘rocket’
	b. país	[pa.ˈis]	‘country’
	c. paisaje	[paj.ˈsa.xe]	‘landscape’

Due to the interaction of stress with high vowels and syllabic position, it has been claimed that glides are allophones of high vowels (Harris 1983, Roca 1997, Hualde 2005). However, there are many words, exemplified in (5), that do not always conform to that rule since they show realizations with the vowels separated into different syllables (i.e. in hiatus).

(5)		*hiatus*		*diphthong*	
	a. dueto	[du.ˈe.to]	or	[ˈdwe.to]	‘duet’
	b. bienio	[bi.ˈe.njo]	or	[ˈbje.njo]	‘biennium’
	c. piara	[pi.ˈa.ɾa]	or	[ˈpja.ɾa]	‘herd of pigs’

The examples in (5) show two possible realizations, one with the sequence in a hiatus and one with the sequence in diphthong. Hualde (2004) refers to these examples as *exceptional hiatus*, and many of them are shown to have a morphological justification for the hiatus realization. In many words, the high vowels fail to diphthongize if the word is paradigmatically related to forms where it bears stress. For example, the word in (5a) is paradigmatically related to the word ['du.o] ‘duo, pair’; whose high vowel bears stress, and therefore it does not diphthongize. Equally, vowel sequences at morphemic boundaries of a compound word, such as the example in (5b), also fail to diphthongize: the example in (5b) is made up with the root *-enio*, related to the word *año ('year')*, which bears stress on the first vowel; the morphemic boundary preceding the root prevails the vowel sequence from creating assimilation. Finally, there are a number of words like that in (5c) that are not morphologically justified, but which also have a possible realization in hiatus. Hualde (2004) points out at the patterns that the cases such as (5c) fulfill: they are usually word initial, almost all have rising sonority, and the stress falls on either the second vowel of the sequence or on the following syllable:

> The exception to the gliding rule in […] are words where the historical tendency *ia* > *ja* has been blocked. At an earlier historical point Spanish must have had a robust contrast between diphthongs created from the breaking of /ɛ, ɔ/ and original sequences of hiatus. The contrast has tended to lose ground because of the "anti-hiatus tendency" in the language […].
>
> What needs to be explained is thus why contraction has been blocked in specific contexts. For morphologically-justified exceptions, the explanation is more or less clear […]. But what about cases without morphological justification? To repeat, almost always these exceptional hiatus words contain sequences of rising sonority which meet the two conditions of initiality and proximity to stress (before it).
>
> (Hualde 2004: 381)

On the one hand, the motivation for the initiality condition (referring to the fact that the vowel sequence is always in the first syllable) needs to be explored further, and it is partly assumed to be a factor influencing hiatus resolution in this dissertation. In chapter two it will be claimed, however, that the position of a vowel sequence in initial position also contributes to the information retrieval of the word: a hiatus realization ensures a greater duration for each of the vowels in the sequences, which allows for a clearer articulation of each vowel. As a consequence, a better perception of those sounds is ensured. On the other hand, stress has been widely studied as a motivating factor for hiatus versus diphthong contrasts, both within and across word boundaries (refer to section 1.4.1.2 for a review).

The diphthong/hiatus alternation may be diachronically explained (Hualde & Chitoran 2007). When we look at the development from Latin to Spanish, the universal anti-hiatus tendency that derived into diphthongization in Spanish was *exceptionally* (in Hualde's 2004 terms) preserved in a number of words, due to morphological reasons or in strong positions like initial or adjacent-to-stress syllables. This is exemplified in (6) below.

(6)	(L)	pre.t[i.u]m	>	(S)	ˈpre.c[jo]	'price'
but						
	(L)	d[i.a]bolum	>	(S)	d[i.ˈa]blo	'devil'

Hualde (2004) also suggests that the Latin cases have led, by analogy, to the realization in hiatus of other new borrowed words in Spanish, such as *piano* as [pi.ˈa.no], which explains the hiatus realization of certain words in the language.

A study by Simonet (2005) on [CiV] syllabification intuitions of native speakers of Spanish confirms the apparent ambiguity of vowel sequence realization. The results of his experiment show a categorical contrast between hiatus and diphthong based on longer or shorter duration of the vowel sequence. However, it also shows that there are certain prosodic contexts -those of exceptional hiatus- which lead to ambiguous syllabification intuitions, suggesting an intermediate stage between the two categories, i.e. a continuum from diphthongization to hiatus. As duration increases, perception of hiatus is only possible in positions with enough durational substance.

A comparison of exceptional hiatus with sequences of non-high vowels reveals interesting facts in this respect, suggesting a gradient approach for a phenomenon that ranges from hiatus to diphthongs and this in turn to monophthongization (Aguilar 1999). Certain words with non-high vowel sequences, such as example (4a) (*cohete* 'rocket'), can undergo syneresis ([ko.ˈe.te] → [ˈkwe.te]). These changes are purely phonetic in Iberian Spanish, when duration of the vowel sequence reduces in certain contexts, such as a familiar context, where the speech rate is faster. Although highly marked in Iberian Spanish, diphthongized forms in Mexican Spanish have lexicalized: the form in hiatus means 'rocket' and the form with a diphthong 'fireworks'[4]. The *cohete* examples involving non-high vowel sequences suggest an analogy of processes to those of the piano examples (above); that is, hiatus-to-diphthong realizations. Thus, between the Iberian ([ko.ˈe.te] hiatus and the Mexican [ˈkwe.te] diphthong, the existence of a purely phonetic form could be suggested which then would have an ambiguous realization in Iberian Spanish. Thus, Iberian Spanish can be defined as being a gradient language with respect to this feature, and Mexican Spanish as a categorical language.

Conditions of initiality and stress are determinant, but not the only factors that motivate exceptional hiatus-like realizations. In fact, pragmatic factors must also be

[4] Observation brought up by Hualde and reflected in Marisol Garrido's work of her PhD dissertation (personal communication), on diphthongization of non-high vowel sequences in Latin American Spanish (*Diphthongization of Non-High Vowel Sequences in Latin American Spanish*, PhD. diss., University of Illinois at Urbana-Champaign, 2008).

considered in the analysis of vowel sequences, not only within word boundaries, but also across them (Aguilar 1999, 2003; Aguilar & Machuca 1995, Alba 2005, Casali 1997, Dauer 1983, Gow et al. 1996, Hualde & Chitoran 2003, Nespor & Vogel 1986 and Quilis 1981). Across word boundaries, faster speech rate motivates a decrease in the duration of the vowel sequence that also leads to diphthongization, or to other types of hiatus resolution strategies. The case of exceptional hiatus may just be part of a broader process that affects all vowel sequences in order to adequate their realization to the most optimal perception of those sequences. This aspect is also taken into account in the present work, as revealed in the next section.

1.4. A literature review on hiatus resolution

The following section reviews a number of studies on hiatus resolution in Spanish on the factors that affect the production of VV-sequences and the status quo of hiatus resolution in Spanish. They focus mainly on the phonemic contrast between hiatus and diphthong. They also analyze in depth the effects of duration and stress mostly. Still, a more detailed study on other factors that affect the resolution of hiatus, as well as a further classification of all the different strategies that resolve it are needed. The review of the different contributions provided in this section lead to a number of questions on the classification of the strategies that resolve hiatus and shape up the present work. This section is divided into two main parts: section 1.4.1 describes the various *factors* that appear to affect hiatus resolution and section 1.4.2 compiles the different *strategies* in the literature that are used to avoid hiatus in Spanish.

1.4.1. Factors facilitating hiatus resolution

The main factors that have been confirmed to affect hiatus resolution are the following: duration, stress, vowel quality, codas, word type, frequency of use and familiarity and intentionality of the speech act.

1.4.1.1. Duration

As regards to the phonological status of high vowels in Spanish in hiatus/diphthong alternations, Aguilar (1999) studied the acoustic properties of vowels in hiatus and diphthong categories in two different contexts: a reading task and a dialogue-oriented task. Aguilar analyzed the phonetic cues of all possible combinations of rising sonority sequences, that is sequences of [i, u] + [a, e, o]. She also analyzed the effects of the presence or absence of stress in the diphthongs and the effects of stress in the first or the second vowel in hiatus. Her overall results showed that hiatus are longer than diphthongs both in speech and reading tasks, regardless of the quality of the vowels involved in the sequence. Duration is one of the acoustic cues that distinguish both categories for vowel sequences, i.e. hiatus and diphthongs; but not only. Within each of these categories, hiatus and diphthong, her results showed that vowel quality also affects the duration of the sequence in a way that supports the importance of duration as a cue to distinguish hiatus from diphthong. Hiatus with [a] were longer than hiatus with mid vowels, since vowel [a] has a greater duration than mid vowels. However, duration only does not account for the categorical distinction, since the opposite behavior was observed for diphthongs: that is, diphthongs with [a] showed a shorter duration than diphthongs with mid vowels. Durational distinctions were reflected in the F1 and F2 formant trajectories of the vowel sequences, showing that vowels in diphthongs tend to centralize and, thus, observing the formant trajectory of the vowel sequences, the degree of curvature in F2 from one vowel to the other in the sequence is smaller for a diphthong than it is for hiatus. F2 movement has to cover a longer distance in hiatus than in diphthongs from one vowel to the other. Thus, duration is required to be greater for hiatus. If durational reduction occurs, the distance in the F2 trajectory has to reduce, leading to the centralization of the vowels. This articulatory reduction is also reflected in the results based on the speech situations: the faster the speech, the more durational reduction for articulation; and thus, more chances for phonetic diphthongization to take place. Indeed, Aguilar (1999) showed less hiatus instances in the dialogue task than in the reading task.

The durational distinctions between hiatus and diphthong shown in Aguilar (1999) were also confirmed in a study by Hualde & Prieto (2002). Their experiment on

[ia] versus [ja] sequences shows two well defined categories with different durational values. However, their study showed there is a certain amount of variation and overlap between both categories, which leads Hualde & Prieto to suggest the influence of other factors as determinant as durational reduction.

1.4.1.2. Stress

Aguilar (1999) showed tat stress also influences duration in vowel sequences. For diphthongs, stressed sequences were longer than unstressed ones. But hiatus sequences were studied with stress on either the first or second vowel in the sequence; and the results showed longer duration of the sequences for stress bearing high vowels [i, u], that is the initial elements of the sequence. Differences in duration were observed within each category; however they did not affect the distinction between hiatus and diphthong.

Aguilar (1999) suggested a category to classify the strategies of hiatus resolution, which reflects the effect of durational reduction: *monophthongization*. Monophthongization refers to the reduction of a vowel sequence to a single vocalic segment. For diphthongization to take place, at least two of the following three conditions must be met: (i) a continuous formant movement from a frequency area to another, (ii) F1 and F2 at lower areas than in hiatus and (iii) a reduction in duration. Aguilar also distinguishes *deletion* of one of the vocalic segments (['ie] → [e]) from v*ocalization of a diphthong*, when a new vocalic segment appears as the phonetic representation of a vocalic sequence, which shares properties of the original two segments (['ue] → [o]). Overall, resolution of hiatus in dialogue situation was not high (9% to diphthongization and 2% to monophthongization) compared to diphthongs that resolved in monophthongization (22%).

Hualde & Chitoran (2003) also studied the effects of stress, focusing on [iV] sequence categorization of hiatus versus diphthongs. They analyzed rising sonority sequences in initial positions (exceptional hiatus cases, c.f. page 13). In words with exceptional hiatus, stress is either on the second vowel or on the syllable immediately following. Hualde & Chitoran (2003) show that pretonic vowel sequences have greater duration than those in positions further away from the stressed syllable -this is also confirmed in Simonet (2005). Thus, proximity to stress, which involves longer duration for the sequence, is suggested to block diphthongization. Hualde & Chitoran´s study could support Aguilar's (1999) results that speech situations show more instances of diphthongization than hiatus. If there are more chances for hiatus resolution to occur when duration is reduced, then stress plays a primary role in deciding whether there is resolution or not; since stressed vowel sequences have a greater duration than unstressed ones. However, even if the absence of stress favors hiatus resolution, the probability for hiatus to happen is still high. As Aguilar (1999) proposed, there is not a direct correlation between hiatus and stress. It is true that stress has a primary effect on hiatus resolution, but other factors are also playing a role. Rather than stress being a factor, maybe durational reduction involved in it may be playing a part.

Monroy (1980) analyzed reduction and deletion strategies in vowel sequences across word boundaries, both in stressed and unstressed positions. His results confirmed the idea that assimilation of the vowels is easier in unstressed positions. He saw that stress plays an important role in this preference, since unstressed vowels are better candidates for elision than stressed ones. In fact, when both vowels are stressed, deletion does not occur. When only one of the vowels is stressed there are more chances for elision to occur and when both vowels are unstressed elision alternates with reduction. These results suggested a hierarchy of preference for hiatus resolution strategies in a vowel sequence across word boundaries.

(7) Hierarchy of preference for vowel sequences (Monroy 1980):

hiatus → *reduction* → *diphthongization* → *deletion*

A later study by Aguilar (2003) focuses on sequences involving [a] + [a, e, i] sequences at the word boundaries during the reading of texts. Aguilar studied all possible stress patterns for these sequences in initial, medial and final positions of intonational phrases. Phonetic environment, grammatical category of the words containing the vowel sequences and the frequency of occurrence of these words (cf. Jenkins 1999) were controlled for. Results show a gradual reduction in duration, according to the three types of strategies: hiatus shows longer vowels than reduced and monophthongized vowels, a difference that seems to be significant (p= 0,001). Aguilar

(2003) found that a gradient decrease in duration was directly related to the following hierarchy of vowel sequences, regarding stress: two stressed vowels are longer than an unstressed plus a stressed vowel; which in turn are longer than a stressed plus an unstressed vowel sequence, which are longer than two unstressed vowels:

(8) Hierarchy of preference for hiatus resolution (Aguilar 2003):

$'V'V > V'V > \ 'VV > VV$

The absence of stress favors reduction, but the probability for hiatus to happen is still high; thus, the direct correlation between heterosyllabification (hiatus) and stress is not supported in Aguilar (2003). In contrast, this dissertation proposes that other determinant factors are also important.

1.4.1.3. Vowel quality

Spanish resolves two adjacent vowels through diphthongization, when one of the vowels is high, except in exceptional hiatus cases. When non-high vowels are involved, hiatus is preferred a priori, but, as mentioned before, there are instances of vowel reduction in non-high vowel sequences. Assuming Ladefoged's (1993) account for vowel sonority, less sonorous vowels will undergo reduction (or other strategies) more easily than more sonorous vowels, all other factors being equal. A study by Esgueva (1999) on deletion of vowel sequences focuses on the nature of the vowels involved in the process on deletion. His results suggests a preference for corner vowels (/a, i, u/) to prevail in hiatus over mid vowels, and also back vowels to prevail over front vowels. However, Esgueva (1999) does not provide specific explanations for his results nor for the procedures and the experimental design of his study.

It seems that the type of strategy that will resolve hiatus also partly depends on the quality of the vowels involved in the sequence. Recall from section 1.4.1.1 that Aguilar (1999) proposed a correlation between duration and vowel quality in defining the category of hiatus from that of diphthongs. Added to that, Aguilar (2003) which analyzes the production of sequences /a/ + /a, e, i/ in unstressed positions (in order to neutralize the effect of stress) by Spanish speakers, shows a gradation of preference for different strategies of hiatus resolution based on the quality of the vowels in the sequence: *non-high* > *identical* > *high* for monosyllabification strategies (these include reduction of non-high vowels and diphthongization); *identical* > *high* > *non-high* for coalescence and deletion.

Thus, vowel quality is another relevant factor in hiatus resolution that affects the choice of the strategy to resolve VV-sequences in hiatus. The choice of one vowel or another may be linked to their sonority and their capability of being more perceptible in contexts of reduced perceptibility, such as unstressed syllables.

1.4.1.4. Codas

Since "cues for vowel quality are inseparable from cues for place of a following coda consonant" (Burzio 2002:10), the nature of the resolution strategy on the VV-sequence may be dependent on the type of coda consonant.

Burzio (2002) studied the influence of coda consonants in vowel reduction contexts in English, what he called V-to-C interactions. His study follows Ross's (1972) claim that a special mechanism of stress assignment sensitive to C-place is required in cases such as *Adiróndack* versus *Connéctic[ə]t,* where final syllables with velar (or labial) codas fail to exhibit reduction. Burzio claims that a vowel may not reduce in certain closed syllables because the energy contrast between that vowel and the following coda consonant may not be large enough to make both segments perceptible. Thus, loss of perceptional cues involved in the interaction of vowel to coda articulation motivates reduction in certain cases but not in others.

Previously, Dauer (1983) had suggested that the elements that accompany the vowels play a crucial role in determining the type of reduction the vowel sequence may undergo. Indeed, the more complex the syllables, the more variety of segments can appear, and this includes semivowels or sequences of two vowels linked to a single nucleus. Moreover, heavier syllables are usually better candidates to attract stress, therefore their nucleic vowels are more resistant to reduce or delete in a vowel sequence (Monroy 1980). The following examples by Monroy (1980) illustrate that codas play a crucial role in determining the type of reduction a vowel sequence may undergo.

(9)	a. *casi estaba*	/kasistaba/	vs.	*casi helada*	*/kasilada/
	b. *tú entregas*	/túntɾegas/	vs.	*tú eliges*	*/tulixes/
	c. *cosa estúpida*	/kosastú.../	vs.	*cosa evidente*	*/kosavi.../

The second vowels in the sequences from the leftmost column have codas, whereas the ones in the rightmost column do not. There is a clear preference for deletion in this case of one of the vowels in the sequence when the syllable containing the second vowel of the sequence has a coda.

1.4.1.5. Word type

This factor is relevant for sequences across word boundaries, especially when VV-sequences results from combinations of function or content words. The following examples show a sequence of two content words (10a) and a sequence of a function word followed by a content word (10b).

(10)	a. casa enorme	'huge house'
	b. la edad	'the age'

In example (10a) the chances for hiatus resolution to occur are probably less than in the sequence of example (10b). If this is so, it is due to the fact that a function word followed by a content word may form in the language a *phonological word* (Nespor & Vogel 1986): usually, phonological words correspond to lexical words; but unstressed items such as determiners (*la* in 10b, for example) combine with following content units (*edad* in 10b) into single phonological words. Assuming a prosodic structure organized in a prosodic hierarchy, in which phonological units are organized in a hierarchical structure (Selkirk, 1984), and in which they represent bounded phonological rule domains, phonological words are the domain for syllabification. Thus, in the phonological word in (10b), the vowel sequence may suffer phonetic variation that results from a VV-sequence of two non-high vowels at the origin (recall they are originally syllabified in hiatus). A vowel sequence resulting from a phonological word in this sense, that is, at the phonological word edge, is usually shorter than VV-sequences within other word combinations. Moreover, within the phonological word, any qualitative loss in the vowel sequence is restored more easily; information restoration is faster, due to the fact of having the initial segment of the phonological chain, which is the beginning of the function word (Nespor & Vogel 1986, Quilis 1993).

The notion of information restoration is in part related to the position of the sequence within the word. It is known that word final segments tend to be shorter than word initial ones (Gow et al. 1996, Casali 1997). For that reason, vowel sequences across word boundaries that undergo hiatus resolution usually target the V1, which is the final segment of the first word. It seems logical to claim that the final element of the function word in phonological words, thus, is more easily restored than the V2.

The situation of vowel sequences within word boundaries is somewhat different. In initial positions, reducing features of one of the vowels in the vowel sequence implies loss of crucial information. Thus, hiatus of non-high vowel sequences is less often resolved. Deletion of one of the vowel segments does not occur at all in these initial positions. It is possible to encounter realizations such as (11a) with vowel deletion, but never in the sequence within word boundaries as in (11b).

(11)	a. noche oscura	'dark night'	→	noch[os]cura
	b. teoría	'theory'	→	* t[o]ría

Hiatus resolution is a phonetic phenomenon in Spanish, subject to the effects of durational reduction. Thus, within word boundaries vowel sequences in hiatus may also resolve. In those cases, the target vowel will be expected to be the less sonorous of the two. Spanish often resolves initial vowel sequences in onsetless syllables via fortition, as in (12), or deletion, as in (13):

(12)	hierba 'grass'	/jeɾ.βa/	→	[[ɟeɾ.βa], even [dʒeɾ.βa]
	huerta 'vegetable garden'	/weɾ.ta/	→	[gweɾ.ta]

(13)	Europa 'Europe'	/ew.ɾo.pa/	→	[u.ɾo.pa]
	aerostático 'aerostatic'	/a.e. ɾos.ta.ti.ko/	→	[a. ɾos.ta.ti.ko]

If initial information is most relevant for lexical retrieval, and if maximum contrast among segments is preferred in order to optimize their perception, then it is logical to state that initial positions of a word will tend to have segments that are maximally contrasted.

1.4.1.6. Frequency of use

In his analysis of vowel sequences across word boundaries in New Mexican Spanish, Jenkins (1999), among others, studied lexical factors and frequency effects in hiatus resolution based on Bybee et al. (1994). His work involves analyzing hiatus resolution strategies and examining the conversational speech of 22 native speakers of New Mexico Spanish. His recordings produced 42.2% of diphthongization, 24.6% of deletion of the second vowel and 15.6% of deletion of the first vowel; only less than 10% of hiatus, 7.1% of coalescence and 0.5% of cases epenthesis. An interesting result is that for diphthongization, which at 90% of the cases targeted the first vowel; the remaining 10% are mostly examples where [e] was the second vowel, before an [s] coda. The influence of vowel quality present in the results leads to the conclusion, as also Jenkins suggests, that diphthongization "as a process of hiatus resolution is generally restricted, therefore, to rising diphthongs." (1999: 22). With regard to deletion of the second vowel, most of the examples had an [e] in this position. Jenkins' argument goes two ways to explain the strategy. First, he supports the idea of underspecification of the vowel /e/ in Spanish, that is, that it is not present underlyingly, since all of the words in his data do not have one in other romance languages (Sp-*escuela* It-*scuola* 'school' type of examples) at least in initial position. Secondly, he argues for the frequency effect of the word combination (function or content word combinations) as the reason why deletion of the second vowel is possible: most of these [e] vowels appear in combinations that are very common in the language, such as *la escuela* 'the school'. This, Jenkins suggests that frequency of occurrence contributes to deletion of the second vowel; since information restoration happens easier than if the sequence is less frequent. Frequency is also argued to be the main factor affecting cases with deletion in the first vowel, notably, since almost all of the words with a final vowel (the first vowel in the sequence) are clitics or monosyllabic unstressed words.

A different approach is given in Alba (2005). His contribution to hiatus resolution is based on the variationist approach, focusing on the effect of frequency of use in vowel reduction and its interaction with other phonological factors. Alba (2005) studies reduction and maintenance of hiatus in order to analyze structural factors and frequency effects on hiatus resolution. The structural factors he controls are vowel quality ([a]+[a,e,i,o,u]), stress (in all four possible combinations), syllable type (open or closed), word type (content and function words in all four possible combinations), string class (article+noun, verb+preposition, all others) and morpheme boundaries (whether the first vowel is a root or a suffix). With regard to factors of a usage-base (frequency), Alba (2005) controls previous mentionings of the string containing the vowel sequence, since he argues that the effects of previous mentionings can be accounted for in terms of ease of articulation. He analyzes the number of previous mentionings of the string (in the preceding 5 clauses), the producer (speaker, interlocutor or both) and the form (exact or variation of the string, exact or variation of the word, no previous mentioning). His results show that reduction is highly favored (74%) over maintenance of hiatus (26%), although maintenance is not as rare as previously proposed in the literature. When both vowels are unstressed, reduction is most favored (83%), as opposed to reduction of sequences of two stressed vowels (13%). With regard to vowel quality, /a/ and /e/ favor reduction the most (87% and 78% respectively), followed by /o/ (62%) and then /i/ and /u/ (49%, 51%). Overall, hiatus is reduced more when the second vowel is a low or mid vowel (80%) than when it is a high vowel (51%). Alba (2005) concludes that among all factors, stress, vowel quality, word class, string class and frequency of the word string produced significant effects. However, syllable type, morpheme class and frequency of the independent words did not have a significant effect. He concludes that factors other than phonological, i.e. usage-based, are significant in determining hiatus resolution in Spanish: language is constantly being shaped, variation occurs constantly, and the use of language in production and perception affects mental representations. Alba (2005) assumed this usage-based approach to explain that the effects of frequency of certain word structures (in this case two word ensembles, since we are dealing with vowel sequences at the word edge) are as determinant as factors like stress to predict hiatus resolution strategies. After all, categorization of language items is based on identity or similarity to other established items. Thus, words, the smallest phonological unit in the use-based approach, entail a net of connections to relate items that make storage and accessibility more efficient.

In sum, patterns of the language also play a role in shaping the structure of the vowel sequences (Bybee 2001). If phonetic changes apply to items as language is being used, variants to the predictable forms are created (like the [po.ˈe.ta] > [ˈpwe.ta] case) that are conditioned by the context of their use. Assuming that repetition creates linguistic structures (Bybee & Scheibman 1999), then frequency of occurrence of the vowel sequences in given contexts plays an important role in shaping the realization of those vowel sequences. Thus, more frequent words and in more frequent linguistic contexts should lead to more familiarity (and more accessibility) with the non-linguistic context. Such familiarity and accessibility in context, in turn, may lead to more instances of hiatus resolution strategies, since information restoration is easier; an idea also suggested by Aguilar & Machuca (1995).

1.4.1.7. Familiarity and intentionality of the speech act

Aguilar & Machuca (1995) explore the role of pragmatic factors in the resolution of vowel sequences. They observe that diphthongs in Spanish in spontaneous speech may undergo monophthongization, but also strengthening (reinforcing full vowel qualities in the sequence to maintain hiatus). They aimed at determining the phonetic cues that describe a given speech style chosen by a speaker in a certain context. Specifically, their goal was to investigate the interaction between familiarity between speakers and intentionality of the speech act. They explore the acoustic manifestation of diphthongs [ia, io] (to compare them to realizations of hiatus and single vowels) in four pragmatic contexts: (i) a map task (intentional speech) and (ii) an interview (non-intentional speech) with a familiar and an unfamiliar addressee respectively. Results failed to suggest that a familiar speech or an interview can lead to more realizations of diphthongization or strategies of hiatus resolution. In other words, that familiarity and intentionality are not directly related to durational reduction, However, they did show a direct relation of familiarity in the production of vowel sequences when performing a specific task (map task) addressed to an unfamiliar subject, through a greater number of hiatus and diphthong strengthening. Not familiarity, but carefulness in the specific task performance addressed to an unfamiliar subject revealed to produce more hiatus resolution. What is also relevant from these results is that they measured durational distinctions among the three categories of hiatus, diphthong and vowel, proving a gradient durational reduction; frequency of appearance of these strategies differentiates the speech style that each speaker chose. Aguilar & Machuca's study suggests that hiatus resolution occurs when duration of the vowel sequences is reduced, regardless of the speech style chosen. However, familiarity with the context is important to define the carefulness of the phonetic production.

1.4.1.8. Further remarks on factors

The conclusions drawn so far suggest that resolution of hiatus in Spanish occurs due to the effect of a great number of factors, which can be segmental, prosodic and usage-based. However, the influence of some of these factors seems to be rather relevant, while others show variability in the behaviour of the resolution. This is the case of stress, for example. All of the studies presented so far have taken into account the effects of stress on the vowel sequences, showing that stress blocks resyllabification of a vowel sequence in hiatus. This dissertation is concerned with those cases in which hiatus resolution strategies apply. For that reason, only unstressed sequences have been studied. The goal is to understand what strategies can be predicted and to what extent, that is, what are the contexts where they may apply, under a certain number of factors. Thus, before moving on to a proposal, the following section describes the various strategies provided in the literature that Spanish uses to avoid hiatus.

At this point, however, a clarification is due concerning speech style. Speech style refers to whether the rate of speech is faster or slower; or if it is conversational or lecture-like. Llisterri (1992) analyzes the different labels used to define speaking styles in linguistic research: (i) *spontaneous* versus *connected* speech, (ii) *continuous*, *professional*, *and careful* versus *casual* speech and (iii) *reading style*. They are only part of the names given to describe the data collection in phonetic and phonological studies. Llisterri (1992) claims the need of a standardization of both, the data collection procedures and the labels and definitions of the speaking styles. His material is classified into two main groups:

> *"…one consisting in speech produced in more or less unprepared situations and the other consisting in speech read from a previously prepared text; the latter has been labelled "connected speech", and the former "spontaneous speech" following the conventions adopted by the authors of the papers."*
>
> (1992:3)

Hiatus resolution is related to Llisterri's *spontaneous speech* in Spanish and the studies mentioned throughout section 1.4.1 show that durational factors contribute to this phenomenon (c.f. Aguilar 1999 and 2003; this claim is also discussed in section 2.1). Llisterri (1992) observes that in hiatus co-articulation is analyzed in acoustic and articulatory studies, whose data collection comes from connected and spontaneous speech. However, spontaneous speech is usually obtained in relatively controlled situations. It refers to data obtained from semi-directed interviews, where informants answer to questions by the experimenter, often in spaces that are unnatural contexts for the informants. Other times, spontaneous speech is motivated through a particular task assigned to the informant, often constrained to elicit phonetic or phonological information.

Connected speech refers to texts, sentences or words that are read aloud in laboratory conditions. It allows experimenters to distinguish and compare among speaking rates, that is, slow, normal or fast rate. The research done on hiatus resolution in Spanish, the data analyzed, comes mostly from connected speech: the tokens containing the vowel sequences are embedded in carrier sentences or texts and informants are asked to read them aloud (c.f. Aguilar 1999 and 2003, Hualde & Prieto 2002, Hualde & Chitoran 2003), or the tokens are read in isolation (Simonet 2005). In these studies, however, no indications are given as to what speech rate must be used by the participants. Spontaneous speech procedures are also carried out though the recording of conversations between informants participating in map tasks (Aguilar 1999) and free interviews (Aguilar & Machuca 1995, Jenkins 1999). This dissertation follows the same premises described in the lines above. Chapter 2 describes a production experiment in which subjects were asked to read in a fast speech rate a number of sentences, from which phonetic data was obtained for posterior analysis.

Jenkins (1999) points out that the tokens he extracted for posterior analysis come from an *allegretto* speech (Harris 1969). In his phonological study on speech speeds of a Mexico City dialect, Harris (1969) contrasted speed variations in pronunciation. Harry's study results in a classification for what Llisterri (1992) renames as rates within connected speech: *Largo* (slow and overprecise), *Andante* (naturally careful speech), *Allegretto* (faster, more casual) and *Presto* (extremely fast and unconstrained). The reading style adopted for the production task in this dissertation is, thus, probably close to Harris' allegretto rhythm. Subjects were trained to acquire that rhythm to provide appropriate contexts for hiatus resolution to occur.

1.4.2. Strategies that resolve hiatus

Given the adequate conditions, sequences of two vowels in Spanish may maintain hiatus or undergo resyllabification as well as durational and spectral changes. The strategies that this language uses to resolve vowel sequences in hiatus have been accounted for in the literature under the following categories: vowel reduction, diphthongization, coalescence and deletion. Jenkins (1999) points out that these strategies have also been accounted for in other cross linguistic studies (Casali 1997) and therefore they are not unique to Spanish. However, the predictability, the degree and target of one or another strategy is language specific. There are a greater number of articles dealing with the hiatus/diphthong dichotomy. Notably those studies only analyze [CiV] sequences and exceptional hiatus. However, fewer studies focus on coalescence and deletion.

Jenkins (1999) has considered epenthesis as a hiatus resolution strategy in Spanish. The examples of epenthesis collected by Jenkins are less 0.5% of the complete tokens, only 5 tokens out of the 924 extracted from the recordings. All five examples consisted on the insertion of a [w] glide in [o]+[e, a] sequences, being the second vowel stressed: */o#esto#o#lo#otro/ → [owestwilotro]* and */no#ay/ → [noway]*, for example. A possible explanation for these few cases, he suggests, is the fact that the variety of Spanish of the informants allows vowel rising in final position (i.e. *campo → campu*), leading to a glide in contexts where the final vowel meets another vowel, with a /ou/ diphthong replacing /o/ vowel.

The following sections describe the main hiatus resolution strategies that occur in Spanish that have been reported so far.

1.4.2.1. Vowel reduction

Vowel reduction in phonetic terms usually refers to any strategy that resolves hiatus; in this sense, reduction indicates any change in the durational or spectral information of at least one of the vowels in the sequence. Hualde and Prieto (2002) and Simonet (2005) claim a categorical distinction between hiatus and diphthong, although they agree that, in speech, diphthongization of hiatus is only a strategy in a continuum, at least in terms of durational reduction. Aguilar (1999, 2003) confirms in her studies the durationally gradient phenomenon of hiatus resolution strategies and claims the existence of a well defined category of vowel reduction: diphthongization when one of the vowels is high and reduction, when both vowels are non-high. In the first case one of the vowels becomes a glide; in the second case, one of the vowels loses its nuclearity (modifications of formant frequencies are reported). Both cases involve changes in formants. Aguilar's (2003) proposal extends to all non-high vowels, showing that it is possible for non-high vowels to undergo reduction, or, at least, included in the same category as high vowels, diphthongization.

1.4.2.2. Diphthongization

In the study by Jenkins (1999) diphthongization is found to be the most common strategy of hiatus resolution. It includes resyllabification of hiatus sequences, regardless of whether they contain high vowels or not. According to Jenkins, the most frequent strategy is rising diphthongization, which targets the first vowel in the sequence, mostly when it is a high vowel but also when it is a mid vowel.

Aguilar (1997) reviews three main definitions for diphthongs that are here rephrase as follows:

a) The concatenation of two vowels, perceptively different, in the same syllable (a generally assumed definition).
b) A sequence of a vowel followed by a semivowel (Borzone de Manrique, 1979).
c) A syllable vocalic nucleus containing two stable positions, where one of the vowels is the nucleus and the other a transition sound (Navarro Tomás, 1919; Gil, 1987) (Lehiste & Peterson, 1961).

Traditionally, the semivowel and the transition sound refer to high vowels or glides. However, Alarcos Llorach (1965) mentions the possibility of two non-high vowels within the same syllable ([kɾe.ˈa.ðo] versus [ˈkɾe̯a.ðo]). This is comparable with the first definition, although phonologically diphthongization of non-high vowels cannot occur within word boundaries. Alarcos (1965) suggests that they can occur phonetically in certain speech contexts. Concerning the idea of "perceptively different", the longer the sonority distance between the two vowels is (in terms of sonority hierarchy), the more perceptible those vowels are[5], thus, better candidates to form a diphthong. In a diphthong with a non-syllabic high vowel, the nucleus of the syllable is linked to the most prominent vowel, the syllabic one, and the high vowel remains part of the rhyme.

1.4.2.3. Coalescence

Coalescence refers to the fusion of the original two vowels into a vowel that shares properties of both. In terms of duration, the resulting vowel has an average duration of a single vowel and the frequencies corresponding to a fusion of the original two vowels. In the study by Jenkins (1999), coalescence is the least used strategy in hiatus resolution, maybe because it partly fails to preserve original information and involves deletion of a segment.

1.4.2.4. Deletion

Coalescence and deletion are both considered the same type of strategy by Aguilar (2003): monophthongization, which refers to the outcome of a single vowel in the phonetic realization of a vowel sequence. Deletion occurs when only one of the two vowels is produced. However, it does not seem easy to determine when coalescence or deletion occurs in strict acoustic terms. There is not a clear distinction in previous literature about these two strategies.

---

[5] See Crosswhite (1999) for an overview of the optimal perception of vowels.

1.4.2.5. Summary of strategies

The various resolution strategies mentioned in this section can be grouped into two types depending on the resulting syllabic structure, following Aguilar (2003): monosyllabification (both vowels in hiatus merge into a single syllable) and monophthongization (not only they merge into a syllable, but they also result in a single vocalic segment). The former involves a loss of syllabicity of one of the vowels in the sequence, but features of the original vowels can still be appreciated. When a high vowel is involved, *diphthongization* occurs, and the high vowel becomes a glide; diphthongization of a sequence of non-high vowels is called *reduction*, when one of the vowels loses its syllabicity. Monophthongization occurs when only one vowel is realized, either by *coalescence*, because both original vowels have merged into a new one which maintains features of both original vowels, or by *deletion* of one of the original vowels. The following figure summarizes the strategies involved in hiatus resolution as they are suggested in previous literature:

Figure 2
Strategies of hiatus resolution in Spanish

$$\text{Hiatus } (\text{V1.V}_2) \rightarrow \begin{cases} \text{Reduction } (.\underset{\frown}{\text{V}}\text{1V2. or . V1}\underset{\frown}{\text{V}}\text{2.}) \\ \text{Diphthongization } (\text{.GV2.or.V1G.}) \\ \text{Coalescence } (\text{.V3.}) \\ \text{Deletion } (\text{.V1 or V2.}) \end{cases}$$

1.5. Hiatus resolution within the phonetics-phonology interface

Spanish hiatus resolution occurs at the phonetic level. Unlike in other languages, it is not a phonological phenomenon and it is speaker dependant. This section addresses the topic of vowel reduction, distinguishing what can be a purely phonological phenomenon from the phonetic strategies that speakers use in given contexts. The issue involves a more general question which is that of the relation between Phonetics and Phonology as two independent disciplines or as two sub-modules of a single approach to the realization and characterization of sounds.

Traditionally, phonetics and phonology have been studied separately, as two autonomous components of the grammar. However, it is inevitably agreed upon that phonetic considerations can increase our understanding of phonological patterns and in turn, phonological systems are arranged to facilitate our ease of articulation and perception (Hayes, Kirchner & Steriade, eds., 2004). For the last two decades now, linguists have questioned the distinction between phonetics and phonology and even proposed they are both part of the same discipline of the grammar concerned with the representation, production and perception of speech sounds. Ohala (1990, 1997) proposes an integrated approach of phonetics and phonology, based on the ideas that (a) phonological units and strategies are motivated by the physical and physiological structure of speech, (b) the speech output is influenced by the need of outcoming as faithful to the phonological representation as possible and (c) the perception of speech is also dependant on the listener's knowledge of the language. On the other hand, Howe & Pulleyblank (2001) defend the hypothesis of Phonetics and Phonology as two independent modules of the grammar: Phonetics studies the physical phenomena (gradient phenomena) of speech production and perception and Phonology is the cognitive science in charge of the categorical representations of speech sounds and strategies. According to this view, however, the content of phonetics and phonology may overlap to a certain degree, when dealing with the mapping of phonological structure into phonetic output.

This dissertation walks along the lines of the integrated approach of phonetics and phonology proposed by Ohala (1990, 1997). This investigation deals with strategies of hiatus resolution in Spanish, which are claimed to be the consequence of the effect of phonetic factors such as durational reduction and vowel contrast maximization in speech production and perception: in order to achieve an optimal perception of the vowels in a sequence, duration in production must allow for complete featural realization of those vowels; however, durational reduction limits that realization, which is more marked as both vowels in the sequence are more alike and, in turn, less marked when they are further apart in the vocalic chart. These effects are phonological, however, leading to a certain amount of prediction for hiatus resolution: always hiatus in word initial vowel sequences within word boundaries (*paellera* type, i.e. [pa.e.ʎe.ɾa] 'pan to cook a Spanish dish'), monophthongization across word boundaries with /s/ coda (*noche oscura* type, i.e. [no.tʃe.os.ku.ɾa] 'dark night') or diphthongization of mid vowels in initial sequences within word boundaries with a stressed V_2 (*cohete* → *[kwe.te]* type, 'fire cracker'). The latter is a clear example of the direct effects of phonetics into phonology, considering that a phonologization strategy has occurred (Barnes 2002) and that what once was a single lexical item has now two independent lexical entries, one in hiatus and another one with a diphthong, in certain varieties of the language. In vowel resolution in Spanish there are, thus, a number of phonetic factors that determine the behavior of certain segments. Specifically, mid vowels rise in order to diphthongize in certain contexts. If diphthongization is a phonological strategy in Spanish, then one could suggest that durational reduction, articulatory adaptation to the speech rate, etc. as phonetic factors interact with the behavior of phonological segments.

For the purpose of this investigation I assume that phonology and phonetics are two independent disciplines within the grammar. However, they feed each other and it is exactly this interface that is at the core of the investigation. The factors that motivate hiatus resolution in Spanish are phonetic (cf. chapter 2), assumed to be motivated by effort minimization and durational constraints. Stress, word type or syllable type, for example, do not directly condition hiatus resolution, but affect it via their effects on vowel duration. Consequently, the strategies to resolve hiatus in Spanish are also phonetic.

I have assumed that categorical patterns are explicable with reference to phonetic tendencies or perceptual limitations (à la Barnes 2002, on the phonologization strategy as a diachronic process). The idea that is favored in this section is that there are differences between phonetic and phonological vowel reduction; however, they are both related, or integrated within a broader linguistic frame. Phonetic vowel reduction refers to undershoot of vowel targets, mainly due to co-articulation and motivated by durational reduction in the speech act. Phonological vowel reduction, however, is the neutralization of vocalic features that may result in a substitution of a phoneme (or allophone) by another; this is dependant of a purely phonological context and the speech act has no effect on it. English is an example of a language with phonological neutralization/reduction. Its inventory contains both [æ] and [ə]. Every time a word such as that (/ðæt/) appears in an unstressed position, the vowel is neutralized and substituted by a schwa (/ðət/). On the contrary, Spanish vowel reduction is phonetic, since its vowel inventory does not allow for phonological vowel substitutions like the English case. Although its underlying vowel inventory is limited to 5 vowels (/a, e, o, i, u/), at the speech act more realizations of those vowels are accounted for (Quilis, 1993).

CHAPTER 2

EVIDENCE OF A GRADIENT HIATUS RESOLUTION: PRODUCTION EXPERIMENT (part I)

This chapter describes the overall design and procedures of a phonetic experiment that investigates hiatus sequences in Spanish and the strategies used in the language to resolve them. The results of this experiment are reported in the next chapter. The hiatus sequences studied include all combinations of non-high vowels in Spanish: /ae/, /ao/, /ea/, /eo/, /oa/ and /oe/. The experiment consists of a production task performed by 8 native speakers of Peninsular Spanish: subjects carried out a reading performance and their production was recorded for posterior analysis. The corpus for the reading production consists of a list of sentences containing words and word pairs with hiatus. This acoustic experiment was conceived to record the subjects' production of those vowel sequences, under the effect of a number of segmental and prosodic factors. The production of these vowel sequences is then classified into the different strategies of hiatus resolution.

2.1. Focus of research and methodology

The phonetic experiment which makes up the core of this dissertation is built upon the studies on hiatus resolution reviewed in chapter 1. All of them lack, in sum, either (i) an account of all factors involved in the experimental part, (ii) a detailed description of all the strategies reflected in the results or (iii) a concise analysis of all the different possible vowel sequences. This section takes all these gaps into consideration in order to build up the corpus for the experiment.

2.1.1. Controlled factors: stress, syllable structure and vowel quality

The effects of stress in the realization of vowels and their acoustic characterization is a well studied topic, specifically in relation to the syllabification of vowels and the issue of high vowel/glide alternation (Harris 1983, Hualde 1991, Rosenthall 1997, among others). It may be recalled from section 1.4.1.2 that stressed vowels are more resistant to hiatus resolution strategies than unstressed vowels (Monroy 1980, Esgueva 1999). Since one of the objectives of this dissertation is to explore the strategies that resolve hiatus, only words where the vowel sequence occurred in unstressed syllables were considered for the experiment, in order to maximize the possibilities of hiatus resolution in adequate contexts.

In Simonet (2005), the duration of syllables is shown to decrease within a continuum as one moves away from the stressed syllable. That is to say, stressed syllables have longer duration than syllables next to stressed ones, and these in turn have longer duration than syllables further away from the stressed one. Therefore, the position of the stress was carefully controlled and the selection of the word for the corpus was made by choosing vowel sequences in syllables adjacent to stressed syllables.

The tokens in the experiment had the stressed syllable right next to the syllable(s) containing the vowel sequences. Within word boundaries, a stressed syllable follows the target vowel sequence, as illustrated in (14) below. Across word boundaries, a stressed syllable precedes the syllable with the V1 in the first word and follows the syllable with the V2 in the second word, as illustrated in (15).

(14) Structure of vowel sequences within word boundaries:

$C_{V1}.{}_{V2}.ˈσ$

Example: [t<u>e.o</u>.ˈɾi.a] *teoría* ‘theory’

(15) Structure of vowel sequences across word boundaries:

$ˈσ.C_{V1}$ # $_{V2}.ˈσ$

Example: [ˈdo.θ<u>e # a</u>.ˈmi.γos] *doce amigos* ‘twelve friends’

The examples in (14) and (15) also illustrate the syllable structure that was used to create the tokens for this experiment (c.f. section 2.1.3). All the tokens varied in syllable length, but none had more than four syllables. Within word boundaries, for the initial vowel sequence to be unstressed, a third stressed syllable at the end of the word was needed. This structure gives oxytone words in Spanish (stress falls on the last syllable of the word, e.g. *maorí* 'maori, from New Zeland', *roedor* 'rodent'). However, paroxytone words (stress falls on the second to last syllable) are more common in the language and, as a consequence, words with a final fourth syllable were used as tokens (e.g. *paellera*, *teoría*, *coagula*). Across word boundaries, the tokens varied between two and three syllable structures, with alternating stresses, bearing in mind that the vowel sequences were unstressed[6].

Finally, concerning vowel quality, only non-high vowel sequences were included in the experiment. As explained in sections 1.2.2 and 1.3, high vowels within a vowel sequence in Spanish easily bring out diphthongization. It was a must in this dissertation to restrict the effect of the various factors in VV-sequence resolution. Thus, only mid and low vowels were considered.

2.1.2. Contexts of hiatus resolution: independent variables and hypotheses

The vowel sequences under investigation were placed in different contexts, based on the factors that are proposed to have an effect on hiatus resolution. Those factors, which act in the experiment as independent variables defined for the production task, are stated below in (16). Each of them is discussed separately in the reminder of this section.

(16) *Independent variables:*

a) Vowel position and quality: combinations of vowels /a/, /e/, /o/, in V1 or V2 positions
b) Word boundaries: within words or across word boundaries
c) Word type: function or content word
d) Syllabic structure: vowel sequences with or without a coda

[6] Refer to table 2 to view the complete set of words used in the experiment.

e) Coda type: nasal, liquid, fricative or plosive coda consonant

2.1.2.1. Vowel position and quality

Certain authors such as Casali (1997) claim that, in a vowel sequence, V1 is crosslinguistically a better target for deletion, and V2 deletion occurs only in languages that also allow V1 deletion. It seems rather logical to think of vowels in V1 position to be better candidates for hiatus resolution than those in V2 position, at least from an articulatory point of view. In effect, there is more gestural overlap between a reduced vowel in V1 position as an onset-like segment to the following vowel than there is for a reduced vowel in V2 position as a coda-like segment to its previous vowel. That gestural overlap allows for a durational reduction in the production of the vowel sequence by targeting V1 rather than V2. Thus, one could expect that V1 reduction should allow more often hiatus to be resolved. The first hypothesis proposed is defined along this line, as follows.

(17) *Working Hypothesis I for hiatus resolution*

V1 suffers durational reduction more often than V2. Therefore, hiatus resolution targets V1 more than V2.

There are, however, a number of studies for Spanish, which suggest that certain vowels are more resistant to hiatus resolution strategies regardless of the position they occupy in the vowel sequence. First, the results in Jenkins (1999), for example, show a higher percentage of V2 deletion in Spanish (refer to section 1.4.1.6) against Casali's (1997) finding of a crosslinguistic preference for hiatus resolution targeting V1 position. Second, Aguilar (2003) notices that durational values the vowel sequences also vary depending on the qualitative nature of the vowels involved, therefore vowel quality directly affects the resolution of hiatus. Taking these claims into account, the vowels involved in the study must be analyzed taking into account their position in the vowel sequence as well as their acoustic characteristics. This study focuses on non-high vowels /a/, /e/ and /o/, in the six possible vowel (sequence) positions: /ae/, /ao/, /ea/,

/eo/, /oa/ and /oe/, thus, in V1 and V2 positions. Recall also that high vowels are not included due to their special status (cf. section 1.3).

Another experimental study by Esgueva (1999) on Spanish vowel sequences also shows other instances of V2 deletion. The results from his experiment suggest a hierarchy of vowels based on vowel quality which plays a role in the decision to select the vowel target for deletion, regardless of position in the vowel sequence. Esgueva (1999) reports the results of the acoustic experiment on vowel deletion in various contexts. He shows that weaker vowels tend to be the target of deletion: in *a+e* or *a+o* sequences the mid vowel; and in *e+o* vowel sequences, the front vowel /e/. Esgueva's (1999) study only reports a number of findings in his experiment, but does not provide an explanation for these. There is not an actual distinction between both mid vowels in terms of sonority in Spanish (c.f. the sonority hierarchy in Hualde 2005:72). However, the front vowel /e/ is considered to be the default vowel in Spanish and has a higher frequency of use than the back vowel. These ideas suggest that the target for hiatus resolution is the vowel that carries the least relevant information that the listener needs for information retrieval. In terms of sonority, the least perceptible vowel is targeted; that is, when both vowels show a similar sonority value, the least marked vowel becomes the target for resolution, allowing durational reduction to take place.

Both Jenkins (1999) and Esgueva's (1999) results suggest that vowel quality may have an effect on the vowel sequence, regardless of the position of the vowel. In terms of sonority, the low front vowel is the most sonorous of the vowels in Spanish (Hualde 2005:72), thus, it can be expected to be more resistant to deletion (or hiatus resolution) than other vowels, leaving the mid vowels to be the target vowels for deletion: *a+e* → *a* and *a+o* → *a*.

In the results from Esgueva (1999), regardless of its position in the sequence, the corner vowel /a/ is more resistant to change (i.e. durational reduction or frequency assimilation to neighboring sounds) than mid vowels; and back vowels more resistant than front ones. Hualde (2005), in his phonological description of V-to-V interaction of vowels in Spanish also confirms the possibility of reduction of mid or low vowels, only in phonetic terms during the speech act. Furthermore, Aguilar (2003) suggested a vowel hierarchy for the different strategies of hiatus resolution based on the quality of the vowels in the sequence. The results from her analysis of vowel sequences in unstressed positions reveal different gradations for each strategy of hiatus resolution analyzed: (i) *non-high* > *identical* > *high* for hiatus, (ii) *high* >*non-high* > *identical* for reduction and (iii) *high* > *non-high* for deletion or coalescence. That is to say, hiatus is preferred more often when both vowels in the VV-sequence are non-high than when both vowels are identical, and this choice, in turn, is more often resolved in hiatus than when one of the vowels in the sequence is high; and so forth in the choice of other strategies. Thus, a second working hypothesis must be stated, that defines the effect of vowel quality in hiatus resolution.

(18) *Working Hypothesis II for hiatus resolution*

Vowel quality affects durational reduction and, therefore, hiatus resolution as follows:

a) More sonorous vowels show longer duration and resist hiatus resolution better than less sonorous vowels: *a* > *e, o*.
b) More marked vowels (in terms of contrastive perceptual cues) show longer duration and resist hiatus resolution better than less marked vowels: *o* > *e*.

The hypothesis under (18) seems to contradict that under (17): vowel quality affects hiatus resolution according to previous literature; but languages seem to prefer to target V1 overall, regardless of the quality of V2: this is probably due to the effect of durational reduction that results from the gestural overlap. To combine both working hypotheses I and II, it can be stated that vowel quality does not play independently from vowel position. Although there are no studies dealing with vowel quality and duration in vowel-to-vowel coarticulation and hiatus resolution specifically, there are a few that deal with those two properties of vowels in other contexts. On the one hand, Gay (1978) suggested that coarticulation of gestures at fast rate of speech involved a compression along the time dimension. In other words, fast rate of speech leads to a decreased duration and an increased movement of coarticulation. On the other hand, Byrd and Tan (1996) found a gestural overlap in VCCV sequences both in heretosyllabic and tautosyllabic sequences in contexts of decreased duration due to a faster speech rate. These results show that shorter duration can induce more gestural overlap between segments. Therefore, it is reasonable to assume that shorter duration can increase hiatus resolution too, leading to a preference for vowel position (V1 targeting) over vowel quality as a constraint determining whether hiatus resolution is more likely to occur under durational reduction. Thus, HYPOTHESIS I is stated as follows:

(19) *Hypothesis I for hiatus resolution*

Hiatus resolution is likely to affect vowels in V1 position more than vowels in V2 position, regardless of their quality.

Another purpose of this dissertation is to throw some light on the effects of vowel quality and vowel position in hiatus resolution. If maximizing the contrast among segments during the speech act motivates changes in the qualitative nature of the vowels involved, then, height and backness may be seen as factors influencing hiatus resolution. But studies seem to conclude that most preferably vowel position affects coarticulation in durational reduction contexts. An analysis of these two features within the two positional contexts will contribute to understand the nature of hiatus resolution based on vowel quality. An analysis of the data from this experiment will help us understand the role of vowel quality in hiatus resolution for V1 and V2 positions.

2.1.2.2. Word boundaries

Phonological boundaries are not necessarily maintained in the phonetic realization of words in connected speech. Thus, a vowel sequence at the word limits is also subject to hiatus resolution. In this dissertation, the term *word boundary* has been adopted to refer to the point where a final and an initial segment of a following word meet. So vowel sequences within the word occur within a single word limits, and vowel sequences across word boundaries are those that are produced when a word ending in a vowel meets another one that starts with a vowel.

Examples such as *casa enorme* ('huge house'), from a native speaker's intuition, allow hiatus resolution. These examples are compared with vowel sequences within word boundaries, as in *paellera* ('pan to make paella'), which may be more restricted in their application of strategies to resolve hiatus. In this study, vowel sequences within word boundaries appear in the first syllable of a word, as in *paellera*, due to the requirements imposed by the controlled factors (refer to section 2.2.1). Effective lexical retrieval is more dependent of word initial material than word final material (Gow et al. 1996). Added to that, word final segments are usually shorter than word initial ones at the word boundaries (Casali 1997). Therefore, word initial vowel sequences are expected to show longer duration, which in turn favors hiatus. On the contrary, a vowel sequence across word boundaries, as in *casa enorme*, will allow hiatus resolution more frequently, especially targeting V1, which correspond to the final segment of the first word. Thus, the second hypothesis is defined as follows.

(20) *Hypothesis II for hiatus resolution*

Hiatus resolution applies more often in vowel sequences across word boundaries than within the lexical word, in which the vowel sequence shows a longer duration.

Although previous studies include word boundaries as a factor in their analyses influencing hiatus resolution (Monroy 1980, Aguilar 2003, among others), they do not take into consideration other factors that are controlled in this study: stress, syllable structure and vowel quality (cf. section 2.1.1).

2.1.2.3. Word type

All the tokens with vowel sequences within word boundaries are *content* words (or lexical words). Within word boundaries, initial information of the word is crucial for information retrieval, due to the fact content words belong to an open class. Thus, the *Initiality Condition* (discussed in chapter 1) makes the vowel sequence resolve in a way that minimum information is lost. That is, we may expect to have a more careful production of the initial syllable of a lexical word, which reflects a longer duration of the vowel sequence and therefore fewer chances for hiatus resolution to occur, as stated under HYPOTHESIS II.

A third hypothesis is proposed in this section, which focuses on vowel sequences across word boundaries and takes into account the nature of the words that make up those vowel sequence focus of the study. Vowel sequences across word boundaries occur in combinations of *content+content*, *function+content* and *content+function* words and they motivate a differentiation between vowel sequences within word boundaries and vowel sequences across word boundaries, as described in the following lines.

Vowel sequences are embedded in content and function word combinations as described below:

a) Across two content words:

a.1) noun + noun:	*Plaza España*	'(name of a square)'[7]
a.2) noun + adjective:	*casa enorme*	'huge house'
a.3) determiner + noun:	*ninguna oferta*	'no offer'
a.4) verb + object:	*siente orgullo*	'(he) feels proud'
a.5) preposition + noun	*desde Asturias*	'from Asturias'

b) Across a function word followed by a content word:

b.1) determiner + noun:	*la edad*	'the age'
b.2) clitic + verb:	*lo acepta*	'(he) accepts it'

c) Across a content word followed by a function word[8]:

c.1) noun + conjunction:	*mañana o*	'tomorrow or'
c.2) verb + preposition:	*irse a*	'(to) go to'

Function words generally undergo reduction more readily than content words due to their lack of lexical content and their frequency of occurrence: as a close class, they are more predictable, and their information, if lost, is more recoverable. Once the frequency of the function words is controlled, they are strongly recoverable from the word following them (Bell et al. 2008). If content words convey lexical information that the listener needs to understand, it is logical to assume that a speaker is more reluctant to target a content word than a function word for hiatus resolution. Along the lines of Bell and colleagues (2008), Aguilar (2003) finds that lexical content is also important

---

[7] There are two tokens within this group that form compound words: /ae/ in *Plaza España* and /oa/ in *Marco Antonio*. In the data analysis of the results, this will be taken into account.

[8] In these cases, there was just a single noun following the preposition, as in *irse a casa* ('(to) go to home') or *mañana o pasado* ('tomorrow or the day after').

for preservation of segmental material. However she suggests that vowel sequences within lexical words undergo less hiatus resolution than vowel sequences in function words. The different factors that seem to affect hiatus resolution, word type included, do not provide accurate predictions so far in the contexts proposed in this dissertation and the literature does not refer to it either. Added to that, it was stated in HYPOTHESIS II (under 20) that vowel sequences within word boundaries resist hiatus more often than vowel sequences across word boundaries. This was due to the fact that word final information may be easily lost, since it is initial information of a word which is necessary for information retrieval. Following HYPOTHESIS II, then, it is logically predictable that vowel sequences in function+content word combinations will resist more hiatus resolution than vowel sequences in other word combinations, assuming that tokens in function+content contexts are considered phonological words (c.f. table 2). That is why including word boundaries as a variable in the experiment will shed some light on possible generalizations about hiatus resolution, and the influence of phonetic realization in linguistic structure.

Function+content word combinations may act as phonological units in certain contexts such as *clitics+verb* (c.f. section 1.4.1.5, Nespor and Voguel 1986). Recall from section 1.4.1.5 that phonological words that act as a single lexical unit and vowel sequences at the initial word edge of these phonological units can easily undergo hiatus resolution; qualitative loss of the vowels is easily restored. Examples such as the sentence *me ha salido bien* ('it turned out ok for me') illustrate this, as follows: the clitic *me* followed by the auxiliary verb *ha* is often pronounced with vowel deletion (V1 deletion): /me/+/a/ > /ma/. In these contexts, hiatus resolution should target V1, which belongs to the function word. VV-sequences in function+content words in this experiment should be expected to behave like vowel sequences within lexical words, that is, as single phonological units which resist hiatus more that vowel sequences across word boundaries. However, due to the fact that lexical information is easier to recover in function words Nespor & Vogel 1986, Quilis 1993, also cf. section 1.4.1.5), then hiatus resolution should affect more often vowel sequences in phonological words containing a function word than vowel sequences within lexical words. If this statement is true, then it should be expected that hiatus resolution targets vowel sequences in function+content words more often than in the other two contexts.

Sequences across content+function words do not form single phonological units and vowels in function words, which do not convey lexical information, are more dispensable than those in content words. Assuming that function words are better targets for reduction, we expect hiatus resolution to occur more often in content+function than in content+content word sequences. The following hypothesis follows from these ideas: (i) vowel sequences in function+content words acting as phonological units show more instances of hiatus resolution than vowel sequences in other contexts based on word type, i.e. content+content or content+function; and (ii) vowel sequences in content+function undergo hiatus resolution more often than in content+content words. As a consequence, a hierarchy of preference for hiatus resolution regarding word type is expected to act on the tokens for the experiment, which is stated next:

(21) *Hypothesis III for hiatus resolution*

Hiatus resolution targets mostly vowel sequences in function+content combinations; less in content+function and far less in content+content combinations.

2.1.2.4. Syllable type

The tokens for the production experiment which analyze VV-sequences within word boundaries have carefully be chosen not to have a coda consonant after the vowel sequence. For tokens across word boundaries, on the contrary, this dissertation compares vowel sequences without a coda (e.g. *ninguna oferta*, 'no offer') to vowel sequences with a coda (e.g. *estaba oscuro*, 'it was dark'). The influence of a coda consonant has an effect on the duration of the vowels in the sequence (Dauer 1983), due to the gestural overlap that occurs in the V-to-C coarticulation. Thus, it may follow that the effects of an adjacent coda on the vowel sequence plays a role in determining the type of hiatus resolution strategy or at least in determining the target vowel for hiatus resolution in those cases.

Assuming an acoustic-articulatory connection between a vowel and the following coda, contexts of reduced perceptibility such as unstressed syllables influence the production of that vowel and the following coda consonant. Burzio (2002) studied the effect of codas in vowel reduction, what he called *V-to-C interaction*, in order to explain vowel reduction in certain contexts of unstressed syllables in English (refer to section 1.4.1.4). He claimed that the possibility for the vowel to reduce depends on its effect of the following coda consonant, due to the sonority interaction between the two segments. In such contexts, for an optimal perception of the V-to-C sequence, the maximum sonority contrast between both segments is necessary. However, this is conditioned by the duration of both the vowel sequence and the coda. Therefore, to maintain hiatus a maximal contrast must be kept with the following consonant, which implies a longer duration for the complete gestural articulation. Otherwise, the syllable must be open, in which hiatus resolution will be favored. The following hypothesis is thus proposed:

(22) *Hypothesis IV for Hiatus Resolution*

Vowel sequences in closed syllables show longer duration and are more resistant to hiatus resolution than vowel sequences in open syllables.

2.1.2.5. Coda type

The relation between the behavior of a vowel sequence and the following coda consonant is related to the perceptibility of those segments and the energy contrast between them, which is also necessary for an optimal perceptibility of the segments (c.f. Burzio 2002). Along the lines of Burzio, a vowel may not reduce in certain closed syllables because the energy contrast between that vowel and the following coda consonant may not be large enough to make both segments perceptible. It follows from this statement that longer duration is needed to produce that effort of contrast, which may be directly related to the degree of probability of having hiatus resolution.

That is why codas with different levels of perceptibility have been compared, based on the sonority scale. Assuming the sonority hierarchy in Hualde (2005:72) (*liquids* > *nasals* > *fricatives* > *stops*), four coda types were considered in the experiment, for vowel sequences across word boundaries. At this point, it must be noticed that in the Spanish varieties of the subjects (North and Central Peninsular

Spanish), stops may fricativize in coda position (Morris 2002, González 2003). For that reason, obstruent codas were considered in general terms (fricatives and stops) and analyzed together. The detailed phonetic realization of those codas was not subject to the present study and therefore was not recorded nor described. However, special attention was paid to the /s/ coda within the obstruent group, and a separate context was defined.

Not much has yet been said in the literature about the special status of this fricative sound as a coda, in contrast to other segments within the obstruent group in Spanish. Its specific acoustic characteristics (its high sonority together with its longer duration in coda position) make it a notably sonorous segment Quilis (1981). It has also been proposed to be syllabic and act as vocalic segments in nucleic positions (see in Blackfoot, Derrick 2006). Quilis (1993:172-173) notices vowel loss in weak positions in Spanish of several varieties in Latin America and New Mexico often results from the vowels' contact with /s/. For instance, in *casetita* ('small house') as [ka-s̩-ˈtita] instead of [kaseˈtita]; or in *no necesito paraguas* ('I don't need an umbrella') as [non-sːˈit-ˈprawas] instead of [no#neseˈsito#paˈrawas]. Additionally, /s/ is the most frequent coda in the language.

The codas that appear in the corpus of the production experiment belong to the initial syllable of the second word in the sequence. They were classified as follows:

a) Nasal coda: mostly /n/ coda, although one token contained a /m/

   E.g. *arte antiguo* 'ancient art'

   este ombligo 'this navel'

b) Liquid coda: all the tokens had a rothic tap (/ɾ/)

   E.g. *este artículo* 'this article'

c) /s/ coda: the study focuses on the apico-alveolar fricative, which in coda position of the vowel sequence preceded another obstruent belonging to the following syllable.

   E.g. *noche oscura* 'dark night'

d) Obstruent coda, excluding the sibilant /s/: all tokens have a /k/ coda, except one token which had a /p/ segment following the vowel sequence.

E.g. *carrera octava* ‘eighth race’
dónde optar ‘where to choose’

Unstressed contexts via durational reduction may favour hiatus resolution as a way to maximize the perceptibility of the vowels in those contexts, where it is compromised. Likewise, if a coda follows the vowel sequence, the production of the vowels may also depend on the nature of that consonant. Assuming the sonority hierarchy described in Hualde (2005: page 72), a lower sonority contrast between the vowels and the coda consonant may produce a lower perceptibility of those segments, due to the shorter sonority distance between them. On the contrary, maximizing the distance between the vowel sequence and the following coda will maximize the sonority contrast and, as a consequence, a better perceptibility of those segments. Additionally, it is assumed that more sonorous consonants have longer duration than less sonorous ones (excluding the special status of /s/) (c.f. Martínez Celdrán, 1984). As a result, it is expected that longer duration of the coda consonant will shorten the duration of the vowel sequence within the amount of energy required for the production of the VVC sound chain. As a result, we may expect to find more instances of hiatus resolution in vowel sequences with more sonorous codas. In the case of the /s/ coda, however, another aspect must be considered. Since it is a very sonorous segment, its high frequency in coda position, its long duration and its close-to-vowel-like quality make it a good candidate to affect the duration and quality of the preceding vowel sequence. In that sense, the /s/ coda is expected to allow greatly hiatus resolution.

In sum, this study presents various coda types in vowel sequences of content+content word combinations: liquid, nasal and obstruent codas. It is expected that the acoustic characteristics of the coda affects the likelihood of hiatus resolution in the following way: hiatus resolution will be less frequent when the coda is an obstruent (except for /s/) and more frequent when the coda is a liquid or a nasal. Thus:

(23) *Hypothesis V for Hiatus Resolution*

a) Vowel sequences are longer and more resistant to hiatus resolution if followed by an obstruent coda (excluding /s/).
b) Vowel sequences are shorter and allow more hiatus resolution if followed by a liquid or a nasal coda.
c) Vowel sequences show durational reduction and hiatus resolution if followed by a /s/ coda.

2.1.3. The corpus

The factors described above shaped up the 8 contexts in which non-high vowel sequences are set for posterior analysis. Each of the vowel sequence from the previous section was embedded in a word or word pair, henceforth *tokens*, conformed to a specific context (as detailed in sections 2.1.1 and 2.1.2). Table 2 on the next page illustrates them (vowel sequences are boldfaced).

The 43 tokens were not recorded in isolation. They were embedded in sentences (one token per sentence) in order to provide a natural context in the production, given the fact that it was a reading task and not spontaneous speech. The tokens were placed regularly towards the middle of the sentence, avoiding placing them right before a pause or at the end of an intonational boundary. For example, a token such as the word pair *aire o* ('air or'), with the /eo/ sequence (underlined) as the object of study, was embedded in the following sentence: *¿Prefieres viajar por aire o mar cuando vas de vacaciones?* ('Do you prefer to travel by air or sea when you go on holidays?'). Appendix A illustrates the complete list of sentences containing each one of the tokens object of the study.

Table 2
Tokens according to their context (based on the independent variables)

			vowel sequences					
			/ae/	/ao/	/ea/	/eo/	/oa/	/oe/
within word boundaries (content words, no coda)			**paellera**	**maorí**	**teatrillo**	**teoría**	**coagula**	**roedor**
across word boundaries	*no coda*	*content+content*	casa enorme	ninguna oferta	doce amigos	clase obrera	cerdo asado	esfuerzo enorme
		function+content	la edad	la orilla	le ayuda	le ofrece	lo acepta	lo eterno
		content+function	---	mañana o	irse a	aire o	vino a	---
	*coda**	*liquid coda*	cabeza erguida	otra orquídea	este artículo	siente orgullo	mano armada	---
		nasal coda	hasta entonces	otra oncena	arte antiguo	este ombligo	Marco Antonio	cuerpo entero
		/s/ coda	Plaza España	estaba oscuro	desde Asturias	noche oscura	mismo aspecto	nuevo estudio
		obstruent coda	---	carrera octava	lenguaje actual	dónde optar	momento actual	---

* Tokens with codas were all *content+content* word combinations.

2.2. Experimental procedures

2.2.1. Subjects

The subjects for the experiment were 4 male and 4 female native speakers of northern varieties of Peninsular Spanish, from the communities of the Basque Country, Galicia, Castile-Leon and Catalonia. Their ages at the time of the experiment were between 25 and 30 years old, except for one of the female speakers, who was 42. At the time of the experiment, all of them were first or second year graduate students at the University of Illinois at Urbana-Champaign. Prior to that, they had lived in their place of origin in the communities mentioned above. Some of them had spent, at most, one academic year in an English speaking country prior to their arrival in Illinois, except for one speaker who had previously lived in the United States for three more years. Table 3 provides a detailed account of the status of each speaker at the time of the experiment:

Table 3
Description of the subjects for the experiment

Speaker	*Gender*	*Description*
A	female	25 years old, Community of the Basque Country 1 year in the UK prior to arrival in Illinois
B	male	28 years old, Community of Castile-Leon 3 years in the US prior to arrival in Illinois
C	male	25 years old, Community of Galicia
D	male	27 years old, Community of the Basque Country
E	male	29 years old, Community of the Basque Country 1 year in the US prior to arrival in Illinois
F	female	42 years old, Community of Catalonia 1 year in the US prior to arrival in Illinois
G	female	28 years old, Community of the Basque Country 1 year in Belgium prior to arrival in Illinois
H	female	25 years old, Community of the Basque Country less than a year in Catalonia prior to arrival in Illinois

2.2.2. Recording

The experiment was carried out in a sound-treated room at the phonetics laboratory of the University of Illinois at Urbana-Champaign during the spring semester 2006. Subjects were asked to read the list of sentences in appendix A, which contained the vowel sequences as described in the previous section. The list of sentences containing the tokens were preceded by three filler sentences at the beginning and followed by three filler sentences at the end. The filler sentences allowed the subjects to familiarize themselves with the reading list and to adapt their rhythm for the recording session. Filler sentences were not included in the posterior analysis, in order to avoid interacting effects. The complete reading set of 43 sentences (plus 6 filler sentences) was read three consecutive times by each subject, making a total of 129 tokens containing vowel sequences for each subject analysis.

Subjects were trained to acquire a more or less constant speech rate throughout their reading task, with a production speed that would be fast enough to allow hiatus resolution strategies to take place. The reading speed was close to *connected speech*, following Llisterri (1992); but it was marked by the native intuitions of the experimenter. Prior to the reading of the corpus sentences, subjects were asked to read 5 sentences in a separate sheet of paper. They were instructed to read them over and over again until a rather fast reading speed was acquired. They were asked to maintain that rhythm throughout the reading task. The purpose of the training was to get the reading to sound as natural as possible and closer to a speech style rather than a reading style. In order not to disturb the adopted rhythm by the subjects, at the actual production (reading) task participants were allowed short breaks at the end of each page of the sentence set, but not during the reading of each page; a longer pause was allowed at the completion of each reading. By maintaining a rhythm that was close to speech rate, participants should have enough durational reduction to motivate hiatus resolution strategies to take place.

The reading task lasted an average of ten minutes for each subject. The production data (subjects' recordings) was recorded with a professional-quality equipment (micro: head-mounted Shure SM10A; recording, CSL 4300B Kay Elemetrics; sampling rate 44.100Hz). Subjects were not familiar with the task they had to perform prior to their actual participation and they were not given any information about the object of the study until their participation was completed. Subjects were asked whether or not they had figured out what the experiment was about, but none of them was able to reveal any information about neither the topic nor the object of the study or the procedures to reach the desired objective.

2.2.3. Object of analysis: dependent variables

The posterior analysis of the data recorded was completed at the phonetics laboratories of University of Illinois at Urbana-Champaign and Florida State University. Hiatus is considered in this dissertation as the sequence of two vowels in heterosyllabic position: [V1.V2]. Since vowels are acoustically defined according to their duration and formant frequencies (Martínez-Celdrán 1984, Quilis 1993), hiatus resolution strategies are based on the characterization of those acoustic features. Therefore, the two main objects of analysis or dependant variables that are analyzed in this experiment are *duration* and *formant frequency*.

All measurements in the production experiment were manually obtained from waveform, spectrogram and spectra exploration using the *Praat* software for speech analysis (by Paul Boersma and David Weenink, www.fon.hum.uva.nl/praat, version 4.6.20, 2007). There were cases in which formant measurements were difficult to obtain; in such cases, the formant tracking algorithm from Praat was used. For contexts where measurements were unclear, a second opinion from a phonetician was used for the sake of a more accurate description.

2.2.3.1. Duration

The duration of each vowel sequence was measured, together with its starting and ending points along the time axis in the waveform and spectrogram. Prior to measuring the vowel sequences from the experiment, average values of single vowels /a, e, o/ were obtained for each subject. In order to provide those values, 6 measurements per vowel were obtained for each reading repetition. The vowels were carefully selected to be in word middle position, in open unstressed syllables, most of the time following an obstruent. The average values of each single vowel are illustrated in the following table, for each subject:

Table 4
Average values of single non-high vowels for each subject (in milliseconds)

Subject	/a/	/e/	/o/
A	*42*	*36*	*35*
B	*36*	*37*	*37*
C	*43*	*37*	*43*
D	*37*	*37*	*42*
E	*54*	*42*	*46*
F	*40*	*34*	*39*
G	*40*	*33*	*39*
H	*39*	*33*	*35*
Average	*41*	*36*	*39*
Average (Monroy 1980)	*65*	*55*	*54*

The average values in Table 4 range from 36 ms to 54 ms for vowel /a/; 33 ms to 42 ms for vowel /e/ and 35 ms to 46 ms for vowel /o/. These values are shorter than values reported in previous literature, as illustrated by the average values from Monroy (1980) for single non-high vowels in unstressed position. The shorter duration of the vowels in Table 4 is probably due to the fact that the values were obtained from a reading task where the rhythm of production was forced to be faster than a regular reading style.

The purpose of measuring single vowels was one of comparison: the addition of the values of those single vowels in isolation results in ideal values of vowel sequences. For instance, adding the values of an /a/ (42 ms) plus an /e/ (36 ms) for speaker A, the expected vowel sequences /ae/ for that speaker should be 42+36=78 ms. The resulting value for the vowel sequence was used to compare the actual vowel sequences from the token to the ideal ones. The finding of shorter values suggests reduction or deletion of one vowel segment in the sequence.

In the experiment, the durational measurements that were first taken were those of the VV-sequences as whole segments, duration of vowel sequences potentially undergoing hiatus resolution. But each vowel segment was measured separately in cases were formant values indicated the presence of more than one vowel in the sequence. Durational changes in each of the vowel elements of the sequences were carefully considered. They were crucial in deciding whether hiatus was maintained or resolved.

2.2.3.2. Formant frequency

Duration is not the only acoustic cue to define the nature of a phonetic vowel sequence. Duration may help understand it, by showing values that approach a specific vowel sequence with ideal vowels. Measuring formant frequency values are also needed to specify the nature of the vowels in the sequences at stake.

Formant values for F1 and F2 were measured for all vowel sequences. The first two formants are decisive to define vowel quality (see Martínez-Celdrán 1984), since F1 correlates with height and F2 with backness. Before the reading task, subjects were recorded producing a sample of the five Spanish phonological vowels in isolation, so that the F1 and F2 values of those vowels could be used as reference later on to compare with the values obtained from the production task. The average F1 and F2 values for the vowels /a/, /e/ and /o/ for each subject are illustrated in table 5 below. Notice that table 5 also includes values for high vowels: high vowel formants were included in order to be able to compare possible rising of mid vowels in diphthongization cases. In the analysis, it was necessary to compare the resulting values of mid vowels to those of mid and high vowels in order to conclude whether rising of those vowels had occurred or not.

Table 5
Average F1 and F2 values (Hz) of single vowels for each subject

Subject	/a/		/e/		/o/		/i/		/u/	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
A	*972*	*1588*	*556*	*2488*	*561*	*1020*	*545*	*2822*	*447*	*676*
B	*807*	*1413*	*545*	*2003*	*496*	*1020*	*479*	*2151*	*430*	*873*
C	*772*	*1472*	*523*	*1971*	*489*	*989*	*423*	*2254*	*406*	*706*
D	*939*	*1522*	*610*	*2216*	*643*	*1102*	*447*	*2527*	*447*	*922*
E	*807*	*1315*	*545*	*1905*	*545*	*856*	*381*	*2265*	*397*	*725*
F	*1000*	*1622*	*706*	*2504*	*639*	*1072*	*556*	*2804*	*523*	*906*
G	*873*	*1741*	*725*	*2347*	*627*	*1069*	*610*	*2626*	*447*	*840*
H	*1102*	*1593*	*627*	*2265*	*643*	*1266*	*561*	*2642*	*512*	*889*
Average	*909*	*1533*	*604*	*2212*	*580*	*1049*	*500*	*2511*	*451*	*817*
Average (Martínez-Celdrán 1984)	650	1300	451	1847	496	1007	347	2193	385	1008

Formant values are speaker dependant and they are influenced by a number of factors, such as gender or dialectal variety of the speaker. Usually female frequencies are higher than male frequencies, for instance, and this table reflects that difference, as shown by the frequency contrast of female speakers in A, F, G and H versus male speakers in B, C, D and E[9].

The frequency values in the data analyzed, for with results are reported in the next chapter, show values that are often similar to the average values in table 5. But there are times in which the values differ from those in table 5. In those cases, the F2-F1 difference is used as criterion for classification of the vowel sequence. Although vowel formant values are relative and speaker dependant, the distance from F2 to F1 is usually similar for each speaker regardless of the contexts in which the vowels are produced (Quilis 1993). Thus, the F2-F1 difference should show similar patterns for each speaker. Table 6 below shows F2-F1 values for each vowel per speaker, based on the values from table 5.

[9] The phonological context, such as adjacent consonantal segments or stress, also influences the frequency values of the vowel sequence, by lowering or raising the values (Martínez-Celdrán 1984). Thus, these are uttered in isolation.

Table 6
F2-F1 difference (Hz) of single vowels for each subject

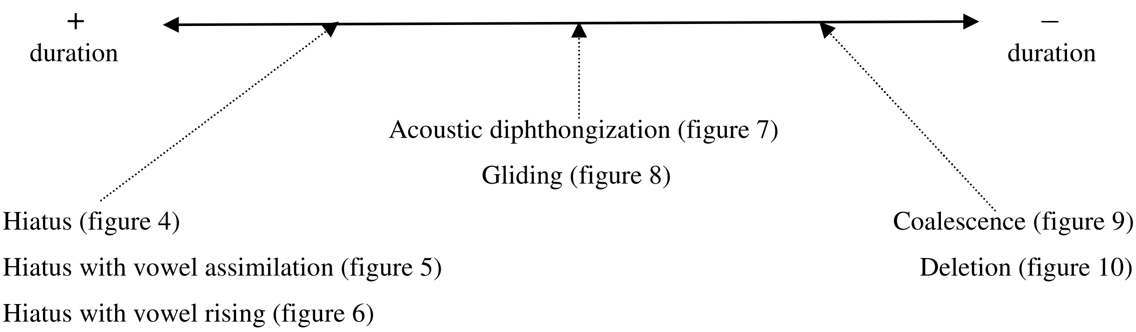
Subject	/a/	/e/	/o/	/i/	/u/
A	*616*	*1932*	*459*	*2277*	*229*
B	*606*	*1458*	*524*	*1672*	*443*
C	*700*	*1448*	*500*	*1831*	*300*
D	*583*	*1606*	*459*	*2080*	*475*
E	*508*	*1360*	*311*	*1884*	*328*
F	*622*	*1798*	*433*	*2248*	*383*
G	*868*	*1622*	*442*	*2016*	*393*
H	*491*	*1638*	*623*	*2081*	*377*
Average	*624*	*1608*	*469*	*2011*	*366*
Average (Martínez-Celdrán 1984)	*650*	*1396*	*511*	*1846*	*623*

2.2.3.3. Hiatus resolution strategy

Although duration and formant frequency are core variables in the experiment (refer to sections 2.2.3.1 and 2.2.3.2), two more variables have been included to complete the study. One of these is the group of strategies that resolve hiatus, or in other words, the syllabic structure that contains the vowel sequence (whether it was hiatus, diphthong or a single vowel, plus their phonetic realization). Based on that, each vowel sequence in the production experiment was classified into the category of hiatus, if reduction did not occur, or into one of the various strategies of hiatus resolution defined as follows: (i) acoustic diphthongization, (ii) gliding, (iii) coalescence or (iv) deletion. This section provides an acoustic description of the three strategies of hiatus resolution encountered throughout the data analysis. The definitions of the strategies are based on the variables (factors), both independent and dependent, considered in the experiment. The data, for which the results are discussed in the next chapter, is analyzed and classified according to these criteria.

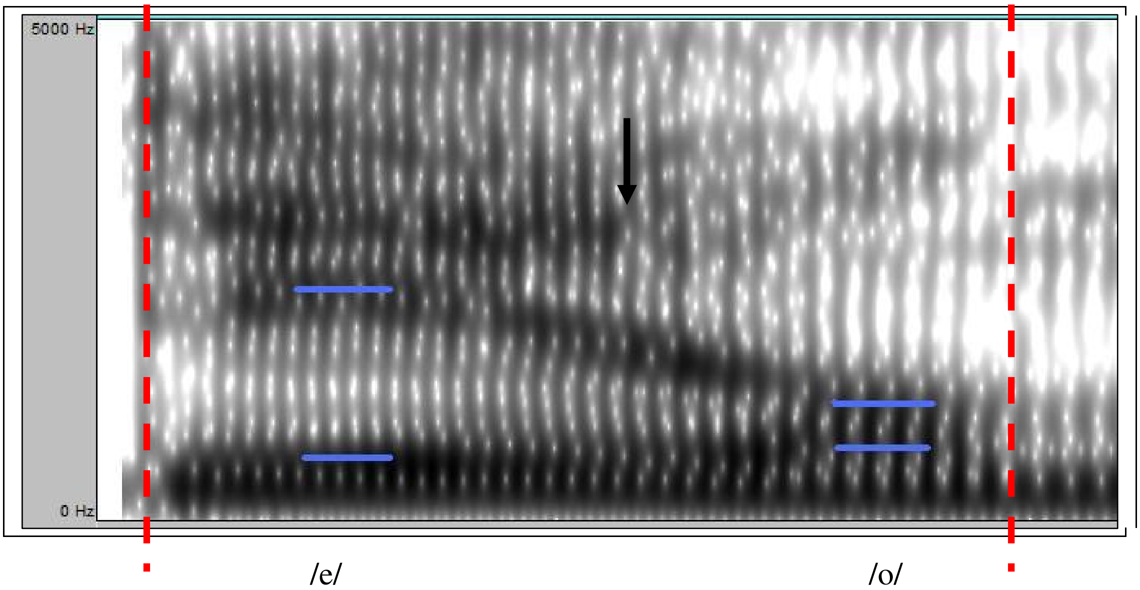
The two main acoustic correlates that define a vowel sequence are duration and frequency. Duration must be considered first, in order to decide whether the vowel sequence produced contains two vowels, a diphthong or one vowel. Then, the quality of the vowel must be measured, by obtaining the formant values for F1 and F2. Sometimes, a change in the pattern of the F3 within the vowel sequence may clarify the point where the first vowel ends and the second vowel starts. Added to that, considering the transitions (abrupt or smooth) from one vowel to the other also helps figuring out the status of the vowels in the sequence with regard to height. Within a durational continuum, figure 3 proposes the various strategies of hiatus resolution explained below.

Figure 3
Hiatus resolution strategies within the time continuum



Along the lines of Martínez-Celdrán (1984:221), vowels in hiatus are defined in the literature as two "autonomous vowels", nuclei of adjacent syllables: acoustically, each vowel maintains its own well defined formant values and the transition from one vowel to the other is shown by an abrupt change in a spectrogram, especially in the F2 value. Throughout the data analysis, instances of hiatus will exhibit the durational values of two full vowels and stable formant frequency values. Figure 4 below exemplifies a hiatus obtained from the data analysis. It is a spectrogram for the vowel sequence /eo/ in the word pair *aire o* 'air or', which was embedded in the sentence *¿Prefieres viajar por aire o mar cuando vas de vacaciones?* ('Do you prefer to travel by air or sea when you go on holidays?'):

Figure 4
Hiatus: spectrogram of the vowel sequence/eo/ in the word pair aire o, by speaker A

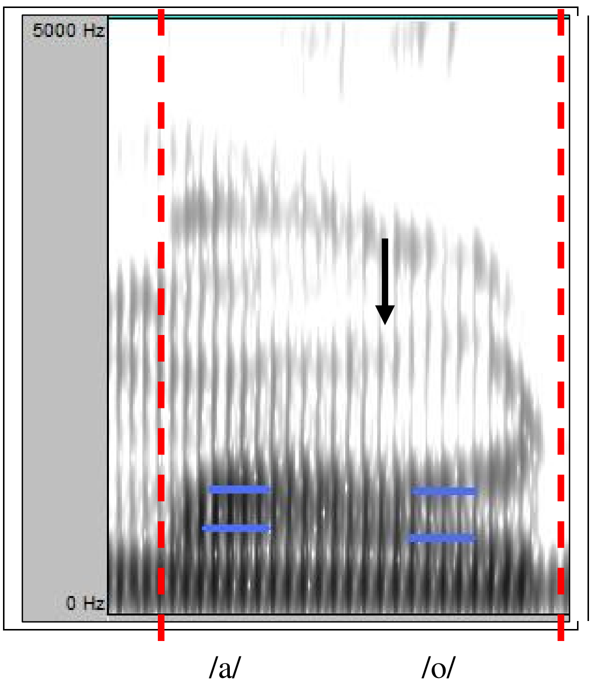


The duration of the complete vowel sequence is 145 ms, which corresponds to the interval between the dotted lines. Based on the durational values for single vowels provided in Table 4, the value for the sequence /eo/ in figure 4 is too large to be that of a single vowel. Moreover, it is possible to distinguish two different stable formant areas in the spectrogram (marked with the short horizontal lines), which suggests there are two vowels in the sequence. The values for the F1 and F2 formants at the marked horizontal line areas are, respectively, 650 Hz and 2250 Hz for V1 and 770 Hz and 1200 Hz for V2. Notice that the F1 and F2 values of these vowels do not correspond to those in table 5. However, the F2-F1 distance does. Therefore, these values correspond to the values of vowels /e/ and /o/.

Although the transition in F2 values from the V1 to the V2 seems to be rather long and smooth, the formant change for F3 is rather abrupt; a clear cut is suggested from V1 to V2 if a vertical line was to be drawn at the point marked by the arrow. At that point, it is also possible to notice a change in the behaviour of F1 and F2: while the formants fade for the first vowel those of the second vowel start to come up. The long transition that F2 shows can be explained by the nature of the vowel sequence. The vowel sequence in figure 4 contains two mid vowels at extreme points in terms of backness: vowel /e/ is a front mid vowel and /o/ a back mid vowel, since F2 characterizes the backness of the vowel. Thus, it seems natural to suggest that the long transition between the vowels is due to the movement the articulators have to accomplish between the front vowel /e/ and the back vowel /o/. Considering the point marked by the arrow as the change from V1 to V2, the durational values are 75 ms for vowel /e/ and 61 ms for vowel /o/.

Hiatus in speech, especially in fast speech, may rarely be produced as exemplified in figure 4, since vowel assimilation in F1 and/or F2 is usually found. Durationally, these cases are still considered hiatus because the vowel sequence shows a durational value that corresponds to two vowels. But in terms of frequency values, at least one of the vowels has undergone changes due to neighbouring sound vowel. Figure 5 illustrates an example of a vowel sequence where vowel assimilation has taken place. In this case, the vowel sequence is /ao/ in the word *maorí*, in the sentence *Es de una tribu m<u>ao</u>rí polinesa* ('He is from a polinesian maori tribe'):

Figure 5
Vowel assimilation: spectrogram of the vowel sequence /ao/ within the word m<u>ao</u>rí, by speaker B

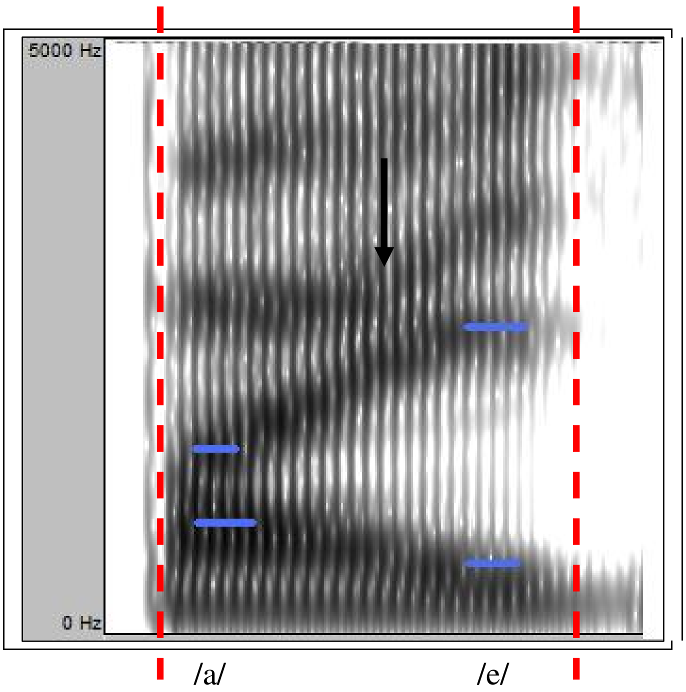


The vowel sequence has a duration of 205 ms, which suggests there are two vowels in the sequence. The spectrogram shows two areas of stable formants, which correspond to different vowels, since they have different F1 and F2 frequency values, as shown through the short horizontal lines. The first vowel has an F1 value of 740 Hz and an F2 value of 1050 Hz. In the second vowel, F1 has a value of 540 Hz and F2 1060 Hz. The latter values correspond to the vowel /o/, but the former values do not correspond to an /a/ of that speaker: the F1 is a little lower than the values expected (909 Hz) and the F2 has the value of an /o/ (1049 Hz) rather than an /a/ (1533 Hz).

At the point of the arrow the formants take a different pattern, especially F3, which suggests a change in the vowel quality. The first vowel measures 109 ms and the second vowel measures 96 ms. Thus, although hiatus is maintained, the first vowel, vowel /a/, has acoustically assimilated to the following vowel (shows formant values that are closer to the following vowel). This simply results in the production of a vowel [a] that is higher (lower F1) and more back (lower F2) than an average one.

A number of tokens show a more extreme case of vowel assimilation, where a mid vowel in the sequence rises to a high vowel. An example of this acoustic realization is illustrated in figure 6 below, for the case of the vowel sequence /ae/ in the word *paellera*, in the sentence *Con la paellera grande pueden hacerse 12 raciones* ('With the big paella-pan one can make 12 servings').

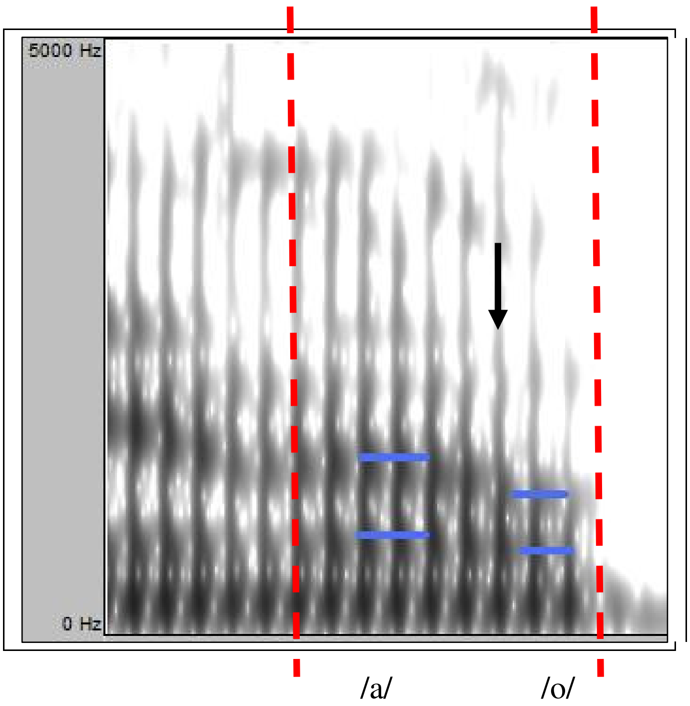
Figure 6
Vowel rising: spectrogram of the vowel sequence /ae/ within the word p<u>*ae*</u>*llera*, by speaker F



The complete vowel sequence lasts 149 ms, which suggests the existence of two vowels in the sequence. Two stable formant areas are observable, marked by the short horizontal lines. For the first vowel, F1 is at 970 Hz and F2 at 1500 Hz. Those formant frequencies correspond to the values of the vowel /a/. For the second vowel, the values are 615 Hz for F1 and 2530 Hz for F2. These values correspond more closely to the values of a /i/ than of /e/. The vertical arrow marks the change in the formant patterns, especially for F1 and F3. Taking that point as the change from one vowel to the next, V1 measures 82 ms and V2 67 ms, suggesting, again, a hiatus, with vowel rising. The reason for this assimilation is probably due to the following palatal sound [λ], characterized by a high F2 (Quilis 1993).

Notice now the following example under figure 7 in which, unlike the previous examples, durational reduction has occurred. Figure 7 shows the vowel sequence /ao/ in the word pair *mañana o* (‘tomorrow or’), in the sentence *Pablo llega mañan<u>a o</u> pasado por la tarde, pero no recuerdo bien* (‘Pablo arrives tomorrow or the day after in the afternoon, but I don’t remember exactly’).

Figure 7
Acoustic diphthongization: spectrogram of the vowel sequence /ao/ in the word pair mañan<u>a o</u>, by speaker B



The total duration of the vowel sequence, between the vertical lines, is 69 ms, which is closer to the duration of a single vowel than a vowel sequence. Two stable formant areas can be measured: for V1, F1 is at 800 Hz and F2 at 1450 Hz; for V2, F1 is at 735 Hz and F2 at 1190 Hz. Although the transition in F1 is more difficult to appreciate, the F2 formant decreases in the area marked by the arrow; there is a change in the F2 that suggests there is a smooth transition between the two vowels. A change in the pattern of the F3 is also noticeable (indicated by the arrow), which shows the change from one vowel to the other. The first vowel (up to the arrow) measures 49 ms, while the second vowel measures 20 ms. Figure 7 shows a vowel sequence where the V2 has been reduced in terms of duration. Moreover, a slight assimilation of the formants to the first vowel is also observed, since the F1 and F2 values for the vowel /o/ are usually somewhat lower, indicating lowering in height and a slight centralization.

During the speech act, durational reduction may imply a syllabic reorganization of the speech sounds. Thus, resyllabification can be expected. If there is not enough time to produce both vowels in the sequence completely, at least one of the vowels is durationally reduced. That is the case for V2 in figure 7. When reduction in the duration of a vowel is significant, the vowel may lose its syllabicity and it will merge into the syllable of the other vowel in the sequence, breaking syllable boundaries. Although there is not much literature on tautosyllabic non-high vowel sequences, examples like figure 7 show the existence of diphthong-like sequences involving non-high vowels. According to Martínez-Celdrán (1984), the glide in a diphthong has lost its autonomy and its formants look like an appendix of the syllabic nucleus (1984:222). Figure 7 reflects what Martínez-Celdrán (1984) describes for diphthongs: the short duration of the second vowel may force it to depend on the previous vowel. But at this point, a difference is proposed regarding the terminology. The term *diphthong* is well established in the literature referring to VV-sequences within syllable boundaries in which one of the segments is a non-syllabic high vowel, or glide (Hualde 2005). This is why the term *acoustic diphthongization* is proposed, to refer to sequences of non-high vowels across syllabic boundaries that are realized not as a sequence of two full vowels, but as a sequence of two vowels where one is not fully produced. Figure 7 illustrates an *acoustic diphthongization*, which is defined in this dissertation as follows:

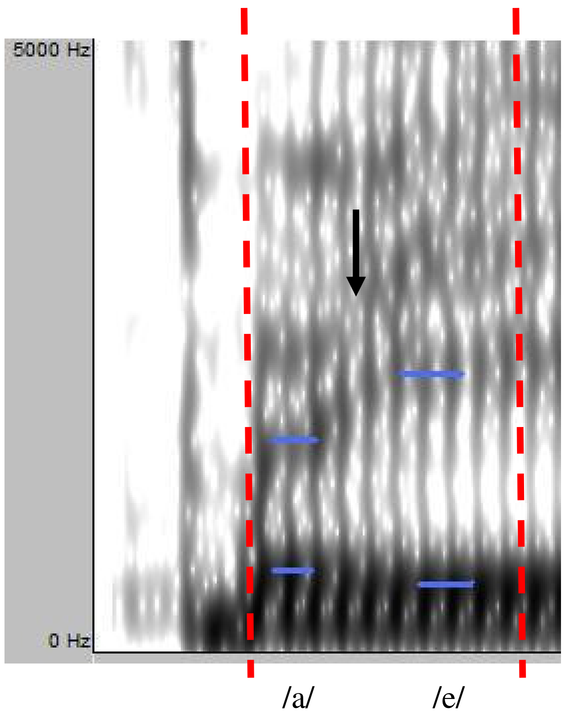
(24) *Acoustic diphthongization:*

[V1.V2] → [.V̯1V2.] or [.V1V̯2.], where V1 and V2 are [-high]

A strategy to resolve hiatus, in which a nucleic non-high vowel in the vowel sequence suffers significant durational reduction. The change may lead to a certain degree of qualitative assimilation to the other vowel in the sequence, showing a smooth transition.

The question arises now if we compare acoustic diphthongization with a vowel sequence that, in order to resolve hiatus, reduces its duration significantly and one of the vowels rises becoming a glide; in other words, the difference between acoustic diphthongization and *gliding*. As opposed to vowel rising, exemplified in figure 6, gliding involves a significant durational reduction and a smooth transition. An example of gliding found in the analysis from the production experiment is given in figure 8.

Figure 8
Gliding: spectrogram of the vowel sequence /ae/ within the word p<u>ae</u>llera,, by speaker A



In this example, the vowel sequence measured 58.6 ms, which is definitely a short value to represent two vowels. However, the spectrogram shows formant values of two vowels (F1=720Hz and F2=1713Hz for the first vowel and F1=557Hz and F2=2315Hz for the second one). The values for the first vowel show an /a/, but the others do not correspond to an /e/ of the speaker. They suggest, instead that the second vowel has risen to a glide. Added to that, a smooth transition from one vowel to the next is shown. This change involves a syllabic reorganization of the vowel sequence and their adjacent consonantal segments (onsets and codas if there are any). Indeed, gliding of a vowel involves a loss in its nucleic status. So for the syllable containing that "glided" vowel, attachment to the following or preceding vowel is necessary. Thus, the following definition is proposed for the strategy of gliding:

(12) *Gliding*[10]

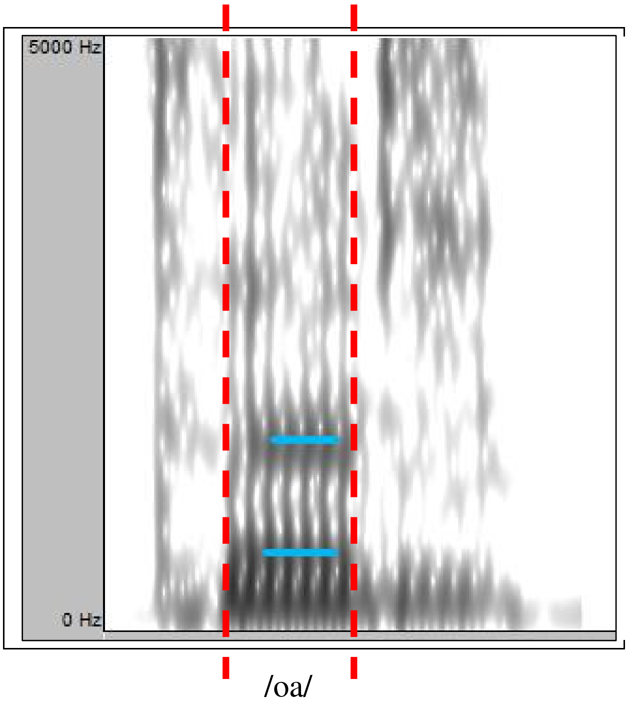
[V1.V2] → [.GV2.] or [.V1G.], where V1 and V2 are [-high]

A strategy to resolve hiatus, in which a nucleic non-high vowel in the vowel sequence suffers significant durational reduction and rises to a glide, showing a smooth transition from one segment to the next. Consequently, the syllable in which the glided vowel is needs resyllabification to the adjacent nucleic vowel.

A further reduction in the duration of the vowel sequence leads to the possibility of producing a single vowel instead of two. In such cases, either complete deletion of one of the vowels in the sequence takes place, or the speaker produces a different vowel in the place of the sequence. Usually, this vowel maintains features of the original vowels. Figures 9 and 10 illustrate examples of a vowel sequence where durational reduction results in the production of a single vowel; coalescence in figure 9, and deletion in figure 10. Both examples show the production of the vowel sequence /oa/ in the word pair *momento actual*, by two different speakers, in the sentence *Con las ventajas de un momento actual como este es preferible que lo hagamos ya* ('With the advantages of a present moment like this one it is better if we do it now'):

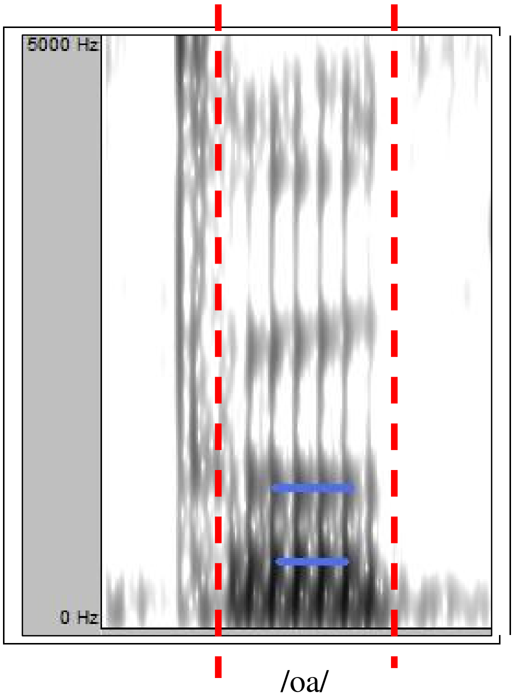
[10] Gliding may result, mostly, when a palatal consonant follows the vowel sequence. It was the case of tokens such as *paellera* (refer to appendix B).

Figure 9
Coalescence: spectrogram of the vowel sequence /oa/ in the word pair momento actual, by speaker A



The vowel sequence in figure 9 lasts 36 ms, which is an average value for a single vowel, based on the durational measures obtained from the data in table 4. In terms of frequency, the values obtained are 620 Hz for F1 and 1610 Hz for F2. The first formant corresponds to the mid vowel [o] rather than the vowel /a/, and the value for the second formant is the value for the central vowel /a/ rather than /o/. In this figure, the vowels have partially assimilated to each other (assimilation to the /o/ in height and assimilation to the /a/ in backness), resulting in a vowel that combines acoustic characteristics from both input vowels.

Figure 10
Deletion: spectrogram of the vowel sequence /oa/ in the word pair momento actual, by speaker C



The vowel sequence in figure 10 lasts 54 ms. Once again, given this short duration, it is not possible to have two vowels in the produced sequence. Moreover, the spectrogram shows stable formant areas for only a single vowel. However, in this case the values for F1 and F2 are 540 Hz and 1190 Hz respectively; those values are closer to the values for the vowel /o/ of that speaker. Although the values are somewhat higher, comparing the production of that vowel to other /o/ vowels for the same speaker allows us to confirm it is a vowel /o/. Comparing figure 9 with figure 10 provides a clear distinction between two phonetic phenomena involving durational reduction: coalescence or deletion. The following definitions are proposed for each:

(26) *Coalescence*

[V1.V2] → V3

Resyllabification of a hiatus into a single syllable, the resulting vowel is a combination of the F1/F2 values of the original vowels.

(27) *Deletion*

[V1.V2] → [V1] or [V2]

Resyllabification of a hiatus into a single syllable, resulting in the deletion of one of the original vowels.

Based on the acoustic correlates of duration and frequency and into account the abrupt or smooth transitions between the vowels, a summary of the strategies of hiatus resolution proposed is provided in the next table. Table 7 in the next page summarizes the acoustic characterization for each strategy. It includes hiatus, which comprises the three variants that were discussed above and exemplified through tables 4, 5 and 6. The strategies described in the following table have served to classify the data that is analyzed in the next chapter.

Table 7
Acoustic description of the strategies of hiatus resolution[11]

		Phonetic representation	*Duration*	*Frequency*	*V1-to-V2 transition*
Hiatus	Hiatus	[V1.V2]	Two vowels	Stable, clearly defined formant values for both vowels.	Abrupt and short
Hiatus	Vowel assimilation.	[V1.V2]	Two vowels	Stable formant values for two vowels. The assimilated vowel shows F1 and/or F2 values closer to the values of the adjacent vowel.	Abrupt and short
Hiatus	Vowel rising	[V_{+high}.V2.] or [V1.V_{+high}]	Two vowels	Stable formant values for two vowels. One of the vowels shows formant values of a high vowel	Abrupt and short
Hiatus resolution strategies	Acoustic diphthong.	[.V̯1V2.] or [.V1V̯2.]	More than one vowel but less than two	Stable formant values for one vowel. Reduced vowel shows formant values close to the original vowel.	Smooth
Hiatus resolution strategies	Vowel gliding	[.GV2.] or [.V1G.]	More than one vowel but less than two	Stable formant values for one vowel. The reduced vowel shows formant values close to those of a high vowel.	Smooth
Hiatus resolution strategies	Coalescence	[V3]	One vowel	Stable formant values for one vowel, showing an F1 value of the V1 and F2 value of V2, or vice versa.	No transition
Hiatus resolution strategies	Deletion	[V1] / [V2]	One vowel	Stable formant values for either the first of second vowel only.	No transition

---

[11] Strengthening of the vowel sequence, as briefly discussed on section 1.4.1.7, is not included in the table. It is true that certain strengthening strategies may require lengthening the duration in the speech chain due to the inclusion of another segment before the vowel sequence. However, this dissertation focuses on the strategies that directly affect the duration and/or the quality of the vowel sequence via durational reduction.

2.2.3.4. Vowel target

Vowel target refers to the vowel in the sequence that undergoes durational or qualitative changes due to the occurrence of a strategy of hiatus resolution. This vowel may appear in V1 or in V2 position. In the analysis of the data, a vowel is considered to be the target of a hiatus resolution strategy if durational and/or frequency values are altered from expected original approximate values of single vowels. Sometimes only one of the vowels in the sequence was the target, sometimes both (in coalescence), or none (if hiatus is maintained).

One of the main questions that this dissertation seeks to answer is to what extent the strategies of hiatus resolution target the first vowel in the sequence, along the lines of Casali (1997): based on a survey on sixty-eight Niger-Congo and nineteen non Niger-Congo languages that have vowel elision, Casali (1997) found that, overall, V1 elision was far more common than V2 elision. His explanation is based on the claim that there are certain morphological and prosodic positions that tend to stand out more in order to preserve their contrast. These positions are defined on a phonological basis: languages tend to preserve material that (i) is auditorily salient, (ii) has important lexical content, or (iii) is in word-initial positions, due to the requirements at the speech-processing level.

Casali's survey focused on deletion. But in this dissertation, deletion is assumed to be part of a gradient phenomenon of hiatus resolution: if durational reduction is mainly what motivates gestural overlap, the more durational reduction takes place the heavier the gestural overlap is going to be. Thus, it can be expected that deletion will be the most extreme form of coarticulation, when one vowel takes over the other. Following Casali (1997), we should expect to find V1 targeting generally, and not only for deletion. The experiment in this dissertation seeks to shed some light in this respect, providing theoretical input in phonology: either by showing experimental data that complements Casali's (1997) results or providing examples of V2 targeting and an analysis that explains in what contexts hiatus resolution takes place.

CHAPTER 3

THE EFFECT OF SEGMENTAL AND PROSODIC FACTORS ON HIATUS RESOLUTION: PRODUCTION EXPERIMENT (part II)

3.1. Introduction

This chapter reports the results obtained in the analysis of the production task described in chapter 2. The distribution of the data within this chapter corresponds to the dependent variables described in section 2.2.3: duration, formant frequency, hiatus resolution strategies and vowel target. However, formant frequency results are not discussed in a separate section like the others. Measurements of F1 and F2 of the vowel sequences are included as criteria to classify the different vowel sequences produced into the various hiatus resolution strategies.

First, durational measurements were taken of all the produced vowel sequences that were relevant to the study (refer to table 2). Each subject repeated the production task three times; therefore, three productions were recorded for each token. An average of those values was used in the statistical analyses, which are reported in section 3.2. Second, the formant frequency values were recorded for each segment in each vowel sequence. Thus, based on the observation of duration and formant values, each token was classified within a category of hiatus resolution strategies defined in section 2.2.3.3: hiatus, acoustic diphthongization, gliding, coalescence or deletion. The results from this analysis are reported in section 3.3. Table 8 summarizes the overall percentages of hiatus and hiatus resolution strategies that were produced in the experiment.

Table 8
Production of hiatus resolution strategies

Strategy	Rep.1	N	Rep.2	N	Rep.3	N	*Total*	*N*
Hiatus	16%	52	8%	25	11%	35	*12%*	*112*
Ac. diphthong	18%	60	22%	71	17%	53	*19%*	*184*
Gliding	0%	0	2%	7	1%	3	*1%*	*10*
Coalescence	37%	119	42%	134	46%	146	*42%*	*399*
Deletion	29%	93	25%	80	24%	77	*26%*	*250*
Valid	94%	324	92%	317	91%	314	*92.5%*	*955*
Missing	6%	20	8%	27	9%	30	*7,5%*	*77*

The tokens classified as *missing* refer to those which could not be analyzed. The reasons vary: sometimes duration could not be measured; formants were not clear in the spectrogram, or simply the expected sounds were not produced and therefore not reflected in the waveforms.

Table 8 illustrates the production of the different strategies in general (*total*) and the production of the different strategies by repetition. Familiarity with the reading material or fatigue may be reflected in the production results. For instance, the greatest number of hiatus was produced in the first repetition (16%), suggesting that reading was done more carefully and as a consequence vowel sequences had a longer duration. Repetition 2 shows the smallest amount of hiatus (8%), suggesting that familiarity with the reading context allowed subjects to read faster, thus producing vowel sequences with a shorter duration. Repetition 3 shows a larger number of hiatus than in 2 (11%), which may be the result of certain amount of fatigue in the reading activity. This is also supported by observing the results on gliding. At repetition 1, no instances of gliding were found (0%). Gliding requires the target vowel to rise to a high vowel and this is done as a result of durational reduction. Although the percentage of gliding is very low (only as a consequence of having a palatal approximant following the vowel sequence in one specific token), the greatest amount of production is done in repetition 2 (2%).

Overall, coalescence is the strategy that is used the most (42%), followed by deletion (26%), acoustic diphthongization (19%) and hiatus (12%). These results are consistent with the claim that durational reduction in certain contexts, such as faster speech, motivates hiatus resolution strategies, coalescence being the most common.

Finally, for the strategies which involve significant qualitative changes in one of the vowels in the sequence (that is to say acoustic diphthongization, gliding and deletion), it was observed whether the first vowel (V1) or the second vowel (V2) was the target for reduction. The percentage of V1 or V2 targeting was recorded for each of the strategies of hiatus resolution that are concerned with this variable and the results are reported in section 3.4. Due to the particularly low percentage of occurrence of gliding, the analyses on this strategy are not included in the results displayed.

The statistical analyses run on the results were conducted using SPSS 15.0 for Windows. Due to the design of the experiment, a full interaction ANOVA could not be run and one-way ANOVA tests were run instead.

The hypotheses from section 2.1.2 that are about to be confirmed and/or dismissed are repeated below, for the sake of facilitating the interpretation of the results that are discussed next:

HYPOTHESIS I for Hiatus Resolution

Hiatus resolution is likely to affect vowels in V1 position more than vowels in V2 position, regardless of their quality.

HYPOTHESIS II for Hiatus Resolution

Hiatus resolution applies more often in vowel sequences across word boundaries than within the lexical word, in which the vowel sequence shows a longer duration.

HYPOTHESIS III for Hiatus Resolution

Hiatus resolution targets mostly vowel sequences in function+content combinations; less in content+function and far less in content+content combinations.

HYPOTHESIS IV for Hiatus Resolution

Vowel sequences in closed syllables show longer duration and are more resistant to hiatus resolution than vowel sequences in open syllables.

HYPOTHESIS V for Hiatus Resolution

a) Vowel sequences are longer and more resistant to hiatus resolution if followed by an obstruent coda (excluding /s/).
b) Vowel sequences are shorter and allow more hiatus resolution if followed by a liquid or a nasal coda.
c) Vowel sequences show durational reduction and hiatus resolution if followed by a /s/ coda.

All the statistical analyses in this chapter were run on each speaker as well as pulling all speakers together. However, for purposes of limiting the amount of data reported in this dissertation, only section 3.2, on durational variability of vowel sequences includes the results by speaker. The reason is that most of the analyses run pulling all speakers together in this section revealed no significance, so results by speaker were considered instead.

The remaining of this chapter (sections 3.2, 3.3 and 3.4) presents the results in the same order that was used to present the definition of the various independent variables: vowel position and quality, word boundaries, word type, syllable type and coda type. A final section (section 3.5) sums up the overall results from the production task and provides a discussion that introduces, partly, the general conclusions of this work, which are discussed in chapter 5.

3.2. Durational variability of vowel sequences

This section reports the results of the durational measurements from the acoustic data (section 2.2), which will be used to analyze the durational variations of the vowel sequences under the effect of the different segmental and prosodic factors. As briefly mentioned in the introduction to this chapter, the results in this section are presented following the order in which the independent factors in section 2.1.2 were described.

3.2.1. Effects of vowel position and quality on durational variability

The statistical analyses for vowel position and quality were based on the 6 vowel sequence combinations described in section 2.1.3: /ae/, /ao/, /ea/, /eo/, /oa/ and /oe/. The purpose of this analysis was to examine durational differences based on the nature of the vowels involved in the sequences, specifically concerning features of height (therefore comparing the effects of low vowel /a/ versus mid vowels /e, o/), frontness (/e/ versus /a, o/ and backness (/o/ versus /e, a/). Rather than grouping the production data according to the vowel sequences as such, two major analyses were run based on V1 or V2 positions of the three non-high vowels /a, e, o/: the effects on durational variability of the vowel sequence when V1 is /a/, then /e/ and /o/ and so forth. The results are reported in the next lines. In each group (V1 and V2 positions), the effects of height, frontness and backness on duration are compared.

Table 9 below displays the average duration of vowel sequences based on the nature of V1. The overall results suggest a gradation of durational reduction as follows: o > a > e: the vowel sequences are longest when V1 is a /o/, and shortest when V1 is /e/. However, these differences in duration did not reveal to be significant. A pairwise comparison with a Scheffe post-hoc test for multiple comparisons did not show a significant difference either.

Table 9
Mean duration (in ms) of vowel sequences under effect of V1 quality

Subject	V1=/a/	N	V1=/e/	N	V1=/o/	N	*p*-value	F-value
A	59.74	14	55.25	16	60.87	13	.774	F(2,40)= .258
B	77.06	14	63.88	16	204.40	13	.312	F(2,40)= 1.199
C	59.53	14	54.09	16	61.29	13	.699	F(2,40)= .361
D	65.07	14	59.88	16	55.50	13	.661	F(2,40)= .419
E	80.64	14	65.89	16	70.40	13	.163	F(2,40)= 1.900
F	91.52	14	66.97	16	71.61	13	.051	F(2,40)= 3.202
G	63.16	14	54.79	16	63.31	13	.560	F(2,40)= .589
H	74.79	14	57.06	16	65.89	13	.066	F(2,40)= 2.912
TOTAL	*71.44*	*112*	*59.73*	*128*	*81.66*	*104*	*.223*	*F(2,341)= 1.505*

A second set of analyses was run pulling the vowels into groups, based on vocalic features of height, frontness and backness. The results are displayed in tables 10, 11 and 12. The overall results in Table 10 show a longer duration for vowel sequences that contain a low vowel in V1 position, although this difference did not reveal to be significant.

Table 10
Mean duration (in ms) of vowel sequences under effect of V1 height

Subject	V1=low	N	V1=mid	N	*p*-value	F-value
A	59.74	14	57.77	29	.788	F(1,41)= .073
B	77.06	14	126.87	29	.568	F(1,41)= .332
C	59.53	14	57.32	29	.778	F(1,41)= .080
D	65.07	14	57.91	29	.420	F(1,41)= .665
E	80.64	14	67.91	29	.068	F(1,41)= 3.526
F	91.52	14	69.05	29	.016*	F(1,41)= 6.326
G	63.16	14	58.61	29	.573	F(1,41)= .322
H	74.79	14	61.02	29	.042*	F(1,41)= 4.396
TOTAL	*71.44*	*112*	*69.56*	*232*	*.866*	*F(1,342)= .029*

The only two speakers in table 10 that show a significant difference (F and H) also confirm the general trend above. Speaker B is the exception to the trend, since the performance of this subject shows vowel sequences with a greater duration when the V1 was a mid vowel.

Table 11 displays the average duration of vowel sequences when V1 is either a front vowel or a non-front vowel. The general trend (*total*) suggests a shorter duration when V1 is a front vowel; no significant differences are found, however, except for speaker H.

Table 11
Mean duration (in ms) of vowel sequences under effect of V1 frontness

Subject	V1=front	N	V1=non-front	N	*p*-value	F-value
A	55.25	16	60.29	27	.479	F(1,41)= .512
B	63.88	16	138.37	27	.377	F(1,41)= .799
C	54.09	16	60.38	27	.407	F(1,41)= .703
D	59.88	16	60.46	27	.947	F(1,41)= .005
E	65.89	16	75.71	27	.149	F(1,41)= 2.164
F	66.97	16	81.93	27	.104	F(1,41)= 2.760
G	54.79	16	63.23	27	.278	F(1,41)= 1.207
H	57.06	16	70.50	27	.041*	F(1,41)= 4.465
TOTAL	*59.73*	*128*	*76.36*	*216*	*.122*	*F(1,342)= 2.405*

Table 12 displays the average durations based on backness of the vowel. The analysis shows a greater duration for vowel sequences when V1 is a back vowel, but the difference is not significant.

Table 12
Mean duration (in ms) of vowel sequences under effect of V1 backness

Subject	V1=back	N	V1=non-back	N	*p*-value	F-value
A	60.87	13	57.35	30	.638	F(1,41)= .225
B	204.40	13	70.03	30	.126	F(1,41)= 2.438
C	61.29	13	56.63	30	.559	F(1,41)= .346
D	55.50	13	62.30	30	.452	F(1,41)= .577
E	70.40	13	72.78	30	.743	F(1,41)= .109
F	71.61	13	78.43	30	.488	F(1,41)= .490
G	63.31	13	58.69	30	.575	F(1,41)= .319
H	65.89	13	65.33	30	.938	F(1,41)= .006
TOTAL	*81.66*	*104*	*65.19*	*240*	*.146*	*F(1,342)= 2.126*

In sum, the results displayed in tables 9, 10, 11 and 12 suggest a gradation o>a>e from longer to shorter duration in terms of the quality of V1, even though the results are not significant. Vowel sequences are shorter when V1 is a front vowel, but this result revealed to be significant only for speaker H (table 11). In terms of height, a low vowel in V1 position seems to produce longer vowel sequences, but this trend was only significant for speakers F and H (table 12). With regard to backness, no conclusions can be drawn from the data.

The possible durational effects of vowel quality on V2 position were also examined through similar analyses. Table 13 displays the results of the statistical analysis comparing the three non-high vowels.

Table 13
Mean duration (in ms) of vowel sequences under effect of V2 quality

Subject	V2=/a/	N	V2=/e/	N	V2=/o/	N	*p*-value	F-value
A	59.62	16	58.52	11	57.13	16	.953	F(2,40)= .048
B	175.49	16	65.41	11	76.93	16	.470	F(2,40)= .769
C	59.01	16	51.09	11	61.84	16	.512	F(2,40)= .682
D	57.57	16	49.14	11	70.55	16	.109	F(2,40)= 2.339
E	70.54	16	64.82	11	78.55	16	.252	F(2,40)= 1.428
F	67.71	16	75.59	11	85.56	16	.226	F(2,40)= 1.545
G	60.16	16	50.42	11	66.67	16	.240	F(2,40)= 1.478
H	64.06	16	65.23	11	67.13	16	.921	F(2,40)= .083
TOTAL	*76.77*	*128*	*60.03*	*88*	*70.54*	*128*	*.456*	*F(2,341)= .788*

The results in table 13 do not reveal significant results, nor does the analysis pulling all speakers together (*total*). A longer duration of the vowel sequence is shown when V2 is the low vowel /a/. The shortest duration occurs when V2 is a mid front vowel /e/. However, this difference is not significant. A pairwise comparison with a Scheffe post-hoc test for multiple comparisons did not show significant differences either.

As for V1, a second set of analyses was run on V2, based on height, frontness and backness, in order to search for more accurate results about the effects of vowel quality in V2 position. Table 14 displays the results for vowel sequence duration based on the height of V2. Although the overall results show longer duration for low V2 (76 ms versus 66 ms for mid V2), the results are not significant either.

Table 14
Mean duration (in ms) of vowel sequences under effect of V2 height

Subject	V2=low	N	V2=mid	N	*p*-value	F-value
A	59.62	16	57.69	27	.787	F(1,41)= .074
B	175.49	16	72.23	27	.218	F(1,41)= 1.563
C	59.01	16	57.46	27	.839	F(1,41)= .042
D	57.57	16	61.82	27	.622	F(1,41)= .247
E	70.54	16	72.96	27	.725	F(1,41)= .126
F	67.71	16	81.50	27	.135	F(1,41)= 2.320
G	60.16	16	60.05	27	.989	F(1,41)= .000
H	64.0 V16	16	66.35	27	.734	F(1,41)= .117
TOTAL	*76.77*	*128*	*66.26*	*216*	*.329*	*F(1,342)= .956*

The results in Table 15 below show that vowel sequences are overall shorter when V2 is a front vowel. This is also true for all speakers, except speaker A, whose results show a longer duration of the vowel sequence when V2 is a front vowel. These results are not significant.

Table 15
Mean duration (in ms) of vowel sequences under effect of V2 frontness

Subject	V2=front	N	V2=non-front	N	*p*-value	F-value
A	58.52	11	58.37	32	.985	F(1,41)= .000
B	65.41	11	126.21	32	.516	F(1,41)= .430
C	51.09	11	60.43	32	.265	F(1,41)= 1.279
D	49.14	11	64.06	32	.113	F(1,41)= 2.628
E	64.82	11	74.54	32	.198	F(1,41)= 1.710
F	75.59	11	76.63	32	.920	F(1,41)= .010
G	50.42	11	63.42	32	.129	F(1,41)= 2.398
H	65.23	11	65.59	32	.961	F(1,41)= .002
TOTAL	*60.03*	*88*	*73.66*	*256*	*.253*	*F(1,342)= 1.312*

Finally, the results of the analysis based on backness are displayed in Table 16. Overall, vowel sequences were slightly longer when V2 was a back vowel (70 ms versus 69 ms of non back vowels). This was also the case for all speakers except A and B. However, none of these results revealed to be significant.

Table 16
Mean duration (in ms) of vowel sequences under effect of V2 backness

Subject	V2=back	N	V2=non-back	N	*p*-value	F-value
A	57.13	16	59.17	27	.774	F(1,41)= .084
B	76.93	16	130.64	27	.525	F(1,41)= .411
C	61.84	16	55.79	27	.424	F(1,41)= .651
D	70.55	16	54.14	27	.051	F(1,41)= 4.024
E	78.55	16	68.21	27	.128	F(1,41)= 2.415
F	85.56	16	70.92	27	.112	F(1,41)= 2.634
G	66.67	16	56.19	27	.176	F(1,41)= 1.892
H	67.13	16	64.53	27	.700	F(1,41)= .150
TOTAL	*70.54*	*128*	*69.95*	*216*	*.956*	*F(1,342)= .003*

Summarizing, no significant effects of vowel quality on duration was found in neither V1 nor V2 positions. The results, however, suggest a shorter duration for vocalic sequences including the vowel /e/, both in V1 and V2 positions.

3.2.2. Effects of word boundaries on durational variability

The effects of word boundaries on the duration of vowel sequences were analyzed by comparing the production of those sequences within and across word boundaries (therefore comparing examples such as *paellera* versus *casa enorme*; refer to table 2 for all the cases considered). Table 17 displays the average duration of the vowel sequences within and across word boundaries for each speaker. Duration of the sequences is greater overall within word boundaries (101 ms) than across word boundaries (65 ms), this difference being highly significant (p= 0.14). A closer look at the performance of each speaker reveals similar results. Although speaker B does not show a significant difference in his results, he also produced longer vowel sequences within word boundaries, like the rest of the participants.

Table 17
Mean duration (in ms) of vowel sequences under effect of word boundaries

Subject	Within	N	Across	N	*p*-value	F-value
A	90.99	6	53.13	37	<.001*	F(1,41) = 22.811
B	118.72	6	109.34	37	.937	F(1,41) = .006
C	99.71	6	51.28	37	<.001*	F(1,41) = 43.296
D	102.31	6	53.42	37	<.001*	F(1,41) = 28.217
E	97.95	6	67.86	37	.001*	F(1,41) = 13.096
F	122.40	6	68.90	37	<.001*	F(1,41) = 28.979
G	89.77	6	55.28	37	.001*	F(1,41) = 13.329
H	92.76	6	61.08	37	<.001*	F(1,41) = 15.953
TOTAL	*101.83*	*48*	*65.04*	*296*	*.014**	*F(1,342) = 6.111*

This robust trend suggests a confirmation of HYPOTHESIS II, which states that hiatus resolution applies more often across word boundaries. If durational reduction motivates hiatus resolution, longer duration of the sequences implies less hiatus resolution. In this case, it is shown that duration of vowel sequences within the lexical word are longer than across word boundaries, therefore suggesting they will show less hiatus resolution. Table 17 shows durational reduction across word boundaries, which is, a priori, a more favourable context for hiatus resolution in Spanish.

3.2.3. Effects of word type on durational variability

The statistical analyses run on the results based on word type only account for a subgroup of the complete set of data presented in table 2, namely, on tokens across word boundaries. Three different word type combinations were proposed: content+content (examples such as *ninguna_oferta*), function+content (*la_orilla*) and content+function (*mañana_*o) words (refer to table 2). Table 18 displays the mean durational values of the vowel sequences across word boundaries, based on those word combinations.

Table 18
Mean duration (in ms) of vowel sequences under effect of word type

Subject	Cont.+cont	N	Func.+cont.	N	Cont.+func.	N	*p*-value	F-value
A	48.19	27	59.26	6	77.25	4	.004*	F(2,34)= 6.492
B	122.07	27	71.50	6	80.24	4	.909	F(2,34)=.096
C	47.63	27	66.17	6	53.62	4	.028*	F(2,34)= 3.979
D	47.31	27	64.08	6	78.71	4	<.001*	F(2,34)= 9.597
E	65.78	27	71.46	6	76.48	4	.528	F(2,34)=.651
F	65.14	27	79.64	6	78.18	4	.075	F(2,34)= 2.797
G	50.66	27	63.15	6	74.62	4	.024*	F(2,34)= 4.181
H	56.23	27	73.17	6	75.67	4	.012*	F(2,34)= 5.023
TOTAL	*62.88*	*216*	*68.55*	*48*	*74.34*	*32*	*.812*	*F(2,293)= .208*

The results displayed in Table 18 show a general trend for shorter duration of content+content words (all subjects except subject B). This difference is significant for

5 out of 8 subjects. The durational differences for word combinations involving function words show that content+function words are preferably longer for most of the subjects and only speaker C shows significantly longer duration for function+content vowel sequences. The analyses run on the data pulling all speakers together (*total*), did not show significant differences, however; neither did the posterior pairwise comparison with a Scheffe post-hoc test for multiple comparisons.

The analysis on word type did not reveal significant results. However, three main trends are discovered: (i) vowel sequences are shorter in content+content combinations, results which were significant for 5 speakers; (ii) function+content combinations do not show longer durations, against the expectation from HYPOTHESIS III; and (iii) content+function word combinations may be producing longer vowel sequences, a conclusion that needs further study.

3.2.4. Effects of syllable type on durational variability

The analyses based on syllable type were run in order to check whether the average duration of the sequence was reduced or not when the sequence was followed by a coda consonant (that is, examples in open syllables such as *casa enorme* versus examples in closed syllables such as *cabeza erguida*, refer to table 2). Table 19 shows a robust trend across subjects: 7 of the 8 subjects show significant shorter duration when the vowel sequence is followed by a coda. However, this difference is not significant for all speakers pulled, probably because of the longer values obtained for speaker B.

Table 19
Mean duration (in ms) of vowel sequences under effect of syllable type

Subject	Coda	N	No coda	N	*p*-value	F-value
A	45.38	21	70.86	22	<.001*	F(1,41)= 20.834
B	140.60	21	82.07	22	.473	F(1,41)= .524
C	47.15	21	68.43	22	.002*	F(1,41)= 10.657
D	47.38	21	72.52	22	.001*	F(1,41)= 11.868
E	64.94	21	78.85	22	.032*	F(1,41)= 4.938
F	62.53	21	89.57	22	.002*	F(1,41)= 11.577
G	49.73	21	69.98	22	.005*	F(1,41)= 8.762
H	55.74	21	74.82	22	.002*	F(1,41)= 10.994
TOTAL	*64.18*	*168*	*75.89*	*176*	*.261*	*F(1,342)= 1.270*

Assuming that shorter duration may reflect hiatus resolution, the results in table 19 do not confirm HYPOTHESIS IV, which stated that closed syllables are more resistant to hiatus resolution strategies. In fact, the contrary is suggested.

3.2.5. Effects of coda type on durational variability

The production of the vowel sequences followed by different possible codas was analyzed statistically in order to test their effect on duration (liquid codas as in *cabeza erguida*, versus nasal codas as in *hasta entonces*, also versus obstruent codas as in *carrera octava*, leaving /s/ coda in a forth separate coda type as in *estaba oscuro*; refer to table 2). Table 20 displays the statistical results of the average durations based on coda type. However, these results do not show significant differences.

Table 20
Mean duration (in ms) of vowel sequences under effect of coda type

Subject	Nasal	N	Liquid	N	/s/	N	Obstruent (excluding /s/)	N	*p*-value	F-value
A	43.19	6	39.77	5	51.78	6	46.05	4	.345	*F(3,17)*= 1.184
B	47.75	6	60.70	5	348.80	6	67.44	4	.496	*F(3,17)*= .830
C	42.21	6	46.85	5	43.18	6	60.92	4	.320	*F(3,17)*= 1.258
D	38.38	6	45.32	5	47.07	6	63.90	4	.074	*F(3,17)*= 2.757
E	67.48	6	64.90	5	59.09	6	69.98	4	.885	*F(3,17)*= .214
F	61.61	6	64.57	5	64.18	6	58.90	4	.947	*F(3,17)*= .120
G	48.54	6	45.50	5	41.57	6	69.02	4	.079	*F(3,17)*= 2.696
H	62.08	6	59.82	5	48.81	6	51.52	4	.446	*F(3,17)*= .933
TOTAL	*51.40*	*48*	*53.43*	*40*	*88.06*	*48*	*60.97*	*32*	*.535*	*F(3,164)= .731*

The results in Table 20 do not provide a clear conclusion about the effect of codas in the duration of vowel sequences. The analysis run on all speakers together (*total*) does not confirm any pattern and a pairwise comparison with a Scheffe post-hoc test for multiple comparisons did not reveal any significant differences among groups.

A second set of analyses was run splitting codas into sonorants (liquids and nasals) versus obstruents (including /s/). Table 21 displays a first statistical analysis comparing the two groups. The results obtained from grouping sonorant and obstruent codas together did not reveal significant results, even though they evidence a trend of longer durations with obstruent codas: this appeals to five out of eight speakers (A, B, C, D and G).

Table 21
Sonorants versus obstruents: mean duration (in ms) of vowel sequence under effect of coda type

Subject	Sonorant	N	Obstruent	N	*p*-value	F-value
A	41.63	11	49.49	10	.110	F(1,19)= 2.808
B	53.64	11	236.25	10	.280	F(1,19)= 1.237
C	44.32	11	50.27	10	.425	F(1,19)= .663
D	41.53	11	53.80	10	.071	F(1,19)= 3.656
E	66.31	11	63.45	10	.772	F(1,19)= .086
F	62.95	11	62.07	10	.897	F(1,19)= .017
G	47.16	11	52.55	10	.496	F(1,19)= .482
H	61.05	11	49.90	10	.101	F(1,19)= 2.962
TOTAL	*52.32*	*88*	*77.22*	*80*	*.234*	*F(1,166)= 1.429*

The reason why the difference between the two groups is not significant may be due to the effect of the /s/ coda within the obstruent group. Thus, a second analysis was run, excluding the tokens with a /s/ coda from the obstruent group, are illustrated in table 22.

Table 22
Sonorants versus non-sibilant obstruents: mean duration (in ms) of vowel sequence under effect of coda type

Subject	Sonorant	N	Obstruent	N	*p*-value	F-value
A	41.63	11	46.05	4	.551	F(1,13)= .374
B	53.64	11	67.44	4	.081	F(1,13)= 3.590
C	44.32	11	60.92	4	.142	F(1,13)= 2.449
D	41.53	11	63.90	4	.023*	F(1,13)= 6.693
E	66.31	11	69.98	4	.807	F(1,13)= .062
F	62.95	11	58.90	4	.605	F(1,13)= .281
G	47.16	11	69.02	4	.033*	F(1,13)= 5.715
H	61.05	11	51.52	4	.366	F(1,13)= .878
TOTAL	*52.32*	*88*	*60.97*	*32*	*.022**	*F(1,118)= 5.356*

The results displayed in Table 22 confirm the trend suggested in the previous table: all speakers except F show a greater duration for vowel sequences followed by an obstruent coda. In the analysis run pulling all speakers together, a significant difference is obtained, for the effect of the coda type in the vowel sequence, but not all speakers follow the trend. Vowel sequences with obstruent codas are significantly longer than sequences followed by sonorant codas.

In sum, results in tables 21 and 22 suggest a tendency for obstruent codas (except in the case of /s/) to occur with a longer duration of the vowel sequence, suggesting that durational reduction is more common before sonorant codas. This difference actually reveals, overall, to be significant. Thus, HYPOTHESIS V is partly confirmed. In the case of /s/ codas, the results from table 21 suggest that its effects are influencing the durational values of the obstruent group, implying durational reduction when the VV-sequence is followed by a coda.

3.2.6. Summary

From the results reported in this section, the following conclusions can be drawn:

a) Duration is shorter for vowel /e/ in both V1 and V2 position. If durational reduction motivates hiatus resolution, this result could support the idea that hiatus resolution occurs more often in contexts involving the vowel /e/, which supports working HYPOTHESIS II. But no effects of vowel quality (height, frontness and backness) were found on duration of V1 or V2 overall. Thus, HYPOTHESIS I is partly confirmed, in that vowel quality does not have an effect on hiatus resolution.

b) Longer duration of the vowel sequence is found within word boundaries than across word boundaries, a result which goes along HYPOTHESIS II, if longer duration implies less instances of hiatus resolution.

c) For vowel sequences across word boundaries, two results are to be underlined. First, a general trend reflects the shortest duration for content+content word combinations, a result which runs contrary to HYPOTHESIS III, which stated that content+content contexts would be more resistant to hiatus resolution than other word combination contexts. Second, VV-sequences in function+content combinations revealed to be shorter than content+function combinations. This result partly supports HYPOTHESIS III, which stated that hiatus resolution would be more frequent in function+content than in content+function. If durational reduction motivates hiatus resolution, HYPOTHESIS III is confirmed in this respect.

d) The analyses based on the effect of the variable of occurrence or non occurrence of a coda, showed shorter durations of VV-sequences with a coda than without a coda. These results run against the predictions stated in HYPOTHESIS IV.

e) Regarding coda types in VV-sequences containing a coda, results reveal shorter durations of vowel sequences followed by a sonorant coda than an obstruent coda. The sibilant /s/ coda, however, affects the duration of the vowel sequence different from the rest of the obstruents. Although exact results are not provided in this analysis, its effects imply shorter duration of the vowel sequences. Thus, these results on coda type confirm HYPOTHESIS V.

The analysis on durational variability reveals a number of results that are summarized in the following chart (figure 11) for the sake of clarification of the significant results. Their relevance will be brought up again and further discussed in section 3.5, as part of the conclusion of the overall results.

Figure 11
Durational reduction of vowel sequences in different contexts

Context	*MORE reduction*	*LESS reduction*
1. Vowel position and quality	Front vowel in V1 or V2	Elsewhere
2. Word boundaries	Across word boundaries	Within word boundaries
3. Word type	Content+content	Content+function
4. Syllable type	Closed syllables	Open syllables
5. Coda type	Sonorant coda	Obstruent coda (except /s/)

3.3. Occurrence of hiatus resolution strategies

This section discusses the effect of each independent variable on hiatus resolution strategies. Throughout the section, the different tables displaying the results will include all the strategies of hiatus resolution proposed in the dissertation[12]. For the sake of clarity, once again, the analyses are divided into subsections based on the different independent variables in study.

3.3.1. Effects of vowel position and quality on hiatus resolution strategies

Following the procedures and the order of presentation in the previous section, a first analysis was run for each vowel (/a, e, o/) in V1 and V2 positions in vowel sequences. Subsequent analyses were also conducted concentrating on effects of vowel height (low vowel /a/ versus mid vowels /e, o/), frontness (vowel /e/ versus /a, o/) and backness (vowel /o/ versus /e, a/; refer to section 3.2.1). Table 23 shows the percentages of strategies that occurred under the effect of the nature of the vowel in V1 position. Only the results concerning hiatus and deletion revealed to be significant.

Table 23
Percentage of strategies under effect of V1 quality

Strategy	V1=/a/	N	V1=/e/	N	V1=/o/	N	*p*-value	F-value
Hiatus	15%	312	12%	354	7%	289	.005*	F(2,952)= 5.368
Ac. diph.	18%	312	21%	354	19%	289	.679	F(2,952)= .387
Gliding	2%	312	1%	354	0%	289	.109	F(2,952)= 2.225
Coal.	38%	312	44%	354	43%	289	.220	F(2,952)= 1.515
Del.	27%	312	21%	354	31%	289	.024*	F(2,952)= 3.735

[12] Concerning *gliding*, it will be shown that the results are significantly low in general, although probably not very representative within the general research in this dissertation. Recall that gliding occurred in this experiment as a result of having a palatal approximant following the vowel sequence: within word boundaries in the sequence /ae/ of the word *paellera* ‘pan to make paella’; across word boundaries in the sequence /ea/ of the word combination *le ayuda* ‘(he) helps him’. The results about gliding will be briefly mentioned in this chapter, although they will be further discussed in chapter 5.

There is a greater percentage of hiatus when V1 is the vowel /a/ (15%), then vowel /e/ (12%) and finally vowel /o/ (7%) in that order. A similar trend is revealed for gliding (2%, 1% and 0% respectively). With regard to deletion, a greater percentage occurs when V1 is vowel /o/ (31%), then /a/ (27%) and finally /e/ (21%). A posterior pairwise comparison with a Scheffe post-hoc test for multiple comparisons revealed more specific results: (i) hiatus is produced more often when V1 is the vowel /a/ and least when it is the vowel /o/ (p= .005); and (ii) deletion is more often produced when V1 is the vowel /o/ and least when it is the vowel /e/ (p= .028).

A second set of statistical analyses was run in order to find the effect of vocalic features on the production of the different strategies of hiatus resolution. Table 24 displays the results of the performance of the various strategies of hiatus resolution based on the height of V1. Only the results about hiatus revealed to be significant: hiatus shows a greater percentage when V1 is a low vowel (15%). These results are consistent with the ones reported in table 23.

Table 24
Percentage of strategies under effect of V1 height

Strategy	V1=low	N	V1=mid	N	*p*-value	F-value
Hiatus	15%	312	10%	643	.014*	F(1,953)= 6.011
Ac. diph.	18%	312	20%	643	.472	F(1,953)= .517
Gliding	2%	312	1%	643	.241	F(1,953)= 1.379
Coal.	38%	312	44%	643	.084	F(1,953)= 2.990
Del.	27%	312	26%	643	.602	F(1,953)= .272

The results in Table 25 below on vowel frontness show that the only significant difference is revealed for the percentage of deletion: deletion has a greater percentage of production when V1 is a non-front vowel (29%). This result also partially confirms those in table 23, where back vowel /o/ in V1 position resolves in deletion with a greater percentage of occurrences.

Table 25
Percentage of strategies under effect of V1 frontness

Strategy	V1=front	N	V1=non-front	N	*p*-value	F-value
Hiatus	12%	354	11%	601	.605	F(1,953)= .267
Ac. diph.	21%	354	18%	601	.416	F(1,953)= .663
Gliding	1%	354	1%	601	.395	F(1,953)= .724
Coal.	44%	354	40%	601	.272	F(1,953)= 1.209
Del.	21%	354	29%	601	.011*	F(1,953)= 6.485

Table 26 displays the results on hiatus resolution based on backness[13]. Only the results for hiatus and deletion revealed to be significant, together with the results about gliding. Hiatus shows a greater percentage of occurrence when V1 is a non-back vowel (14%), this difference being highly significant (p= .002). The results on deletion show that it is more often produced when V1 is actually a back vowel (31%).

Table 26
Percentage of strategies under effect of V1 backness

Strategy	V1=back	N	V1=non-back	N	*p*-value	F-value
Hiatus	7%	289	14%	666	.002*	F(1,953)= 9.322
Ac. diph.	19%	289	19%	666	.903	F(1,953)= .015
Gliding	0%	289	2%	666	.036*	F(1,953)= 4.396
Coal.	43%	289	41%	666	.544	F(1,953)= .369
Del.	31%	289	24%	666	.033*	F(1,953)= 4.585

Overall, the results for V1 position suggest that, from a higher to a lower percentage of occurrence, hiatus shows a gradation a>e>o, and deletion a gradation o>a>e. Thus, two mayor conclusions are drawn from the results concerning the quality of V1: (i) a higher percentage of hiatus occurs if V1 if the vowel /a/ and lowest if V1 is

[13] The 0% of appearance or gliding in table 26, may be due to the small percentage of occurrence overall. There were no instances of gliding with a back vowel; they all concerned the vowel sequence /ae/. Thus, the significance in the statistical analysis cannot be taken as robust results as those for deletion and hiatus.

the vowel /o/; and (ii) a higher percentage of deletion occurs when V1 is /o/ and the lowest when V1 is /e/. These results are highly significant so far. Regarding gliding, the results from table 26 revealed a significant preference to resolve hiatus when V1 is [-back], since no instances were recorded of VV-sequences with back vowels in V1 position.

Table 27 below displays the percentages of occurrence of the various strategies based on the nature of the vowel in V2 position. These results reveal significant differences for all the strategies. However, each of the strategies shows a different pattern of preference.

Table 27
Percentage of strategies under effect of V2 quality

Strategy	V2=/a/	N	V2=/e/	N	V2=/o/	N	*p*-value	F-value
Hiatus	7%	358	11%	245	17%	352	<.001*	F(2,952)= 8.895
Ac. diph.	14%	358	13%	245	29%	352	<.001*	F(2,952)= 16.490
Gliding	1%	358	2%	245	0%	352	.039*	F(2,952)= 3.253
Coal.	49%	358	44%	245	33%	352	<.001*	F(2,952)= 9.115
Del.	29%	358	30%	245	21%	352	.021*	F(2,952)= 3.892

Hiatus and acoustic diphthongization show a greater percentage when vowel /o/ is in V2 position (17% and 29% respectively); vowel /a/ in cases of coalescence (49%) and /e/ for gliding and deletion (2% and 30% respectively), even though the results in the last two strategies are very close and the significance of the p-value does not specify which is the vowel that is making the difference in the analysis. Thus, these results just show a possible trend. A posterior pairwise comparison with a Scheffe post-hoc test for multiple comparison, confirms those results: (i) hiatus is more often produced when V2 is a back vowel /o/ and less when it is the vowel /a/ (*p*= <.001); (ii) the vowel /o/ is also preferred in acoustic diphthongization cases, over /a/ (*p*= <.001) and /e/ (*p*= <.001) and (iii) in coalescence cases, /a/ is preferred over /o/ (*p*= <.001) and /e/ (*p*= .029). No significant results were obtained for gliding and deletion.

In order to test vowel quality in a more detailed manner, features of height, frontness and backness were considered for V2 position as well. Regarding height, the results in table 28 reveal highly significant differences for three of the strategies, hiatus, acoustic diphthongization and coalescence.

Table 28
Percentage of strategies under effect of V2 height

Strategy	V2=low	N	V2=mid	N	*p*-value	F-value
Hiatus	7%	358	15%	597	<.001*	F(1,953)= 12.591
Ac. diph.	14%	358	22%	597	.002*	F(1,953)= 9.354
Gliding	1%	358	1%	597	.412	F(1,953)= .674
Coal.	49%	358	38%	597	.001*	F(1,953)= 11.065
Del.	29%	358	25%	597	.158	F(1,953)= 1.992

Hiatus and acoustic diphthongization show a higher percentage of production when V2 is a mid vowel (15% and 22% respectively), unlike coalescence, which is favoured if V2 is a low vowel (49%). Deletion shows the same trend that coalescence does, except that the results are not significant. The low percentage of occurrence of gliding (1%), once again, does not provide significant results for an analysis.

Table 29 shows the corresponding results for the effects of vowel frontness on hiatus resolution strategies. Only a significant difference is revealed for acoustic diphthongization. This strategy is produced less often when V2 is a front vowel (13% versus 21% if the vowel is not a front vowel).

Table 29
Percentage of strategies under effect of V2 frontness

Strategy	V2=front	N	V2=non-front	N	*p*-value	F-value
Hiatus	11%	245	12%	710	.690	F(1,953)= .159
Ac. diph.	13%	245	21%	710	.004*	F(1,953)= 8.212
Gliding	2%	245	1%	710	.077	F(1,953)= 3.144
Coal.	44%	245	41%	710	.397	F(1,953)= .717
Del.	30%	245	25%	710	.135	F(1,953)= 2.233

Finally, in terms of the backness of the vowels, the differences in the results for all the strategies showed to be significant, as illustrated in table 30 below. Hiatus and acoustic diphthongization are more frequent when V2 is a back vowel (17% and 29% respectively), whereas gliding, coalescence and deletion occur more often if V2 is not a back vowel (2%, 47% and 29% respectively). These results are consistent with those reported in table 27.

Table 30
Percentage of strategies under effect of V2 backness

Strategy	V2=back	N	V2=non-back	N	*p*-value	F-value
Hiatus	17%	352	9%	603	<.001*	F(1,953)= 15.442
Ac. diph.	29%	352	14%	603	<.001*	F(1,953)= 32.874
Gliding	0%	352	2%	603	.015*	F(1,953)= 5.923
Coal.	33%	352	47%	603	<.001*	F(1,953)= 16.983
Del.	21%	352	29%	603	.006*	F(1,953)= 7.713

In sum, V2 reveals significant results concerning the three vowels. Hiatus and acoustic diphthongization are preferred strategies when V2 is a back vowel /o/, whereas the VV-sequence resolves via deletion when the V2 is the mid front vowel /e/; coalescence is used if V2 is the low vowel /a/. The results on the effect of back vowel on V2 are also confirmed after a post-hoc test.

Overall, the analyses on the effects of vowel position and quality reveal interesting results on the choice of resolving or not hiatus. Hiatus is shown to be preferred when V1 is the vowel /a/ and least preferred when V1 is the vowel /o/. On the contrary, hiatus is still preferred when V2 is the vowel /o/ and least when V2 is the vowel /a/. Moreover, deletion is the preferred strategy to resolve hiatus when V1 is the back vowel. Added to that, another result concerning front vowel /e/ was also significant: when it appears in V1 position, it shows the fewest instances of deletion; while in V2 position it shows greater number of hiatus.

These results run close to the expectations, a close relation between position and vowel quality, through the data from tables 23 through 30. But they do not serve to confirm HYPOTHESIS I. Further information on vowel target is needed to arrive to conclusions; therefore the results will be discussed in section 3.5. For the time being, it is possible to suggest that if hiatus resolution targets V1 more often than V2 Working HYPOTHESIS I is confirmed; then, vowel /a/ in V1 position results in more hiatus instances, which is partly consistent with HYPOTHESIS I. Hiatus occurs more often if V1 is the vowel /a/ and V2 a mid vowel, whereas deletion occurs more often if the vowel /o/ is in V1 position and the vowel /a/ is in V2 position.

The following chart serves to summarize the significant results obtained from tables 23 through 30. It shows whether or not vowel quality and vowel position have an effect on the possibility of maintaining hiatus or resolving it.

Figure 12
Effects of vowel position and quality on hiatus and hiatus resolution strategies

	Height	Frontness	Backness	V1	V2
Hiatus	*yes (V1 and V2)*	*no*	*yes (V1)*	*yes*	*yes*
Acoustic diph.	*yes (V2)*	*yes (V2)*	*yes (V2)*	*no*	*yes*
Gliding	*No*	*no*	*yes (V2)*	*no*	
Coalescence	*yes (V2)*	*no*	*yes (V2)*	*no*	*yes*
Deletion	*No*	*yes (V1)*	*yes (V1 and V2)*	*yes*	*no*

3.3.2. Effects of word boundaries on hiatus resolution strategies

Once more, the behavior of vowel sequences across word boundaries (*casa_enorme* cases) was compared to similar sequences within the word limits (*paellera* cases; refer to section 2.1.2.2). Table 31 below displays the percentages of production of the various strategies within and across word boundaries.

Table 31
Percentage of strategies under effect of word boundaries

Strategy	Within	N	Across	N	*p*-value	F-value
Hiatus	37%	134	8%	821	<.001*	F(1,953)= 109,678
Ac. diph.	39%	134	16%	821	<.001*	F(1,953)= 39,769
Gliding	4%	134	1%	821	,001*	F(1,953)= 10,940
Coal.	12%	134	46%	821	<.001*	F(1,953)= 60,556
Del.	8%	134	29%	821	<.001*	F(1,953)= 26,717

The results show, on the one hand, a significantly higher rate of realization of hiatus (37%), acoustic diphthongization (39%) and gliding (4%) within word boundaries. On the other hand, coalescence and deletion, which require greater durational reduction, occur significantly more often across word boundaries (46% and 29% respectively).

All of these differences are highly significant and confirm HYPOTHESIS II: within word boundaries hiatus is more often maintained, whereas hiatus is resolved more often under greater durational reduction. The following chart summarizes the results obtained regarding the effects of word boundaries:

Figure 13
Effects of word boundaries on hiatus and hiatus resolution strategies

	Within w.b.	Across w.b.
Hiatus	*yes*	*no*
Acoustic diph.	*yes*	*no*
Gliding	*yes*	*no*
Coalescence	*no*	*yes*
Deletion	*no*	*yes*

3.3.3. Effects of word type on hiatus resolution strategies

The effect of word type for vowel sequences across word boundaries is analyzed through combinations of content and function words. Recall form section 2.1.2.3 that the three word combinations where content+content (as in *ninguna oferta*), content+function (as in *mañana o*) and function+content (as in *la orilla*). The results from the production of the vowel sequences in those three contexts are reported in table 32.

Table 32
Percentage of strategies under effect of word type

Strategy	Cont.+cont	N	Func.+cont.	N	Cont.+func.	N	*p*-value	F-value
Hiatus	5%	595	6%	136	27%	90	<.001*	F(2,818)= 28.233
Ac. diph.	13%	595	18%	136	30%	90	<.001*	F(2,818)= 8.399
Gliding	0%	595	4%	136	0%	90	<.001*	F(2,818)= 13.025
Coal.	51%	595	46%	136	20%	90	<.001*	F(2,818)= 15.362
Del.	31%	595	26%	136	23%	90	.225	F(2,818)= 1.494

The results reveal to be highly significant for all strategies except deletion. In the case of hiatus and acoustic diphthongization, the greatest percentage of occurrence is in content+function words (27% and 30% respectively). However, in the case of content+content words coalescence and deletion show a greater percentage (51% and 31% respectively).

In the case of gliding, although the percentage of occurrence is once again very low (0% for content+content and content+function, 4% for function+content), the significance of the results is revealing: gliding did occur within function+content word combinations, this results, however, may be due to the effect of the following palatal consonant in the tokens[14].

A pairwise comparison with a Scheffe post-hoc test for multiple comparisons confirms the significant difference of content+function effect with the other two categories for hiatus (p= <.001), acoustic diphthongization (p= <.001) and coalescence (p= <.001). In regard to gliding, all the instances of gliding occur in a function+content word across word boundaries which, in the post hoc test, differed significantly from content+content (p <.001) and content+function (p= .002) (no other results revealed to be significant).

The results in table 32 suggest to be running contrary to HYPOTHESIS III, since content+content combinations show higher percentages of hiatus resolution strategies of coalescence and deletion and the opposite was predicted though the HYPOTHESIS. But for function+content combinations, the results do confirm, partly, the predictions, since they also show higher percentages of hiatus resolution strategies of deletion and coalescence than content+function combinations. Added to that, most instances of conten+function combinations show the highest percentages in hiatus and acoustic diphthongization, but the lowest for coalescence and deletion. In sum, hiatus and acoustic diphthongization are more common in content+function word combinations and least preferred in content+content word combinations. The opposite results hold true for coalescence and deletion (even if it is not a significant result).

The following chart serves to summarize the possibility of word type effects on hiatus resolution strategies:

[14] The tokens with the palatal consonant were *le ayuda*.

Figure 14
Effects of word type on hiatus and hiatus resolution strategies

	content+content	content+function	function+content
Hiatus	*yes*	*yes*	*no*
Acoustic diph.	*no*	*yes*	*no*
Gliding	*no*	*no*	*yes*
Coalescence	*yes*	*yes*	*yes*
Deletion	*no*	*no*	*no*

3.3.4. Effects of syllable type on hiatus resolution strategies

The analysis on the effect of syllable type on hiatus resolution strategies refers to vowel sequences where the V2 may or may not be followed by a coda consonant. That is to say, vowel sequences in open syllables (such as *doce amigos*) versus followed by a coda (as in *desde Asturias*, *arte antiguo*, etc; refer to section 2.1.2.4 for an explanation of the context). The results of the analysis are displayed in table 33 below, all of them revealing to be significant results.

Table 33
Percentage of strategies under effect of syllable type

Strategy	Coda	N	No coda	N	*p*-value	F-value
Hiatus	5%	457	18%	498	<.001*	F(1,953)= 45.006
Ac. diph.	13%	457	25%	498	<.001*	F(1,953)= 23.273
Gliding	0%	457	2%	498	.002*	F(1,953)= 9.345
Coal.	53%	457	31%	498	<.001*	F(1,953)= 49.068
Del.	29%	457	23%	498	.034*	F(1,953)= 4.493

According to table 33, hiatus and acoustic diphthongization show a higher percentage of occurrences in open vowel sequences, that is without a coda (18% and 25% respectively), whereas coalescence and deletion occur more often when the vowel sequence appears in closed syllables, sequences followed by a coda (53% and 29%). This results run contrary to HYPOTHESIS V, but in all cases the results are significant. Regarding gliding, the 2% significant value in sequences without a coda is probably simply due to the design of the corpus, which only included codaless VV-sequences that could be assimilating to the following palatal consonant and therefore rise to glides.

Figure 15 summarizes the significant results in the lines above by displaying those strategies in which syllable type contexts may or may not have an effect on hiatus resolution.

Figure 15
Effects of syllable type on hiatus and hiatus resolution strategies

	Coda	No coda
Hiatus	*no*	*yes*
Acoustic diph.	*no*	*yes*
Gliding	*no*	*yes*
Coalescence	*yes*	*no*
Deletion	*yes*	*no*

3.3.5. Effects of coda type on hiatus resolution strategies

The effect of the different codas described in section 2.1.2.5 (/s/, liquid, nasal and obstruent excluding /s/) on vowel sequences is analyzed next. Examples such as *otra orquídea*, with a liquid coda or a liquid consonant following the vowel sequence, was compared to vowels sequences followed by other coda consonants: *otra oncena*, *estaba oscuro* and *carrera octava, for example (cf. table 2). The results are* reported in Table 34, except for gliding, which could not be computed in this section, because there were no tokens within the group of vowel sequences with a coda.

Table 34
Percentage of strategies under effect of coda type

Strategy	Nasal	N	Liquid	N	/s/	N	Obstruent	N	*p*-value	F-value
Hiatus	3%	139	3%	110	3%	119	11%	89	.011*	F(3,453)= 3.786
Ac. diph.	19%	139	5%	110	3%	119	26%	89	<.001*	F(3,453)= 12.658
Coal.	51%	139	60%	110	55%	119	45%	89	.174	F(3,453)= 1.662
Del.	27%	139	32%	110	39%	119	18%	89	.010*	F(3,453)= 3.846

The highest percentage of hiatus and acoustic diphthongization occurs in vowel sequences followed by a non-sibilant obstruent coda (11% and 26% respectively); this context shows the lowest percentage of occurrence in coalescence and deletion (45% and 18%), which happens to be significant (except for coalescence, although it happens to follow the same trend). A pairwise comparison with a Scheffe post-hoc test for multiple comparisons confirms the significant effect on hiatus of obstruents over nasal codas (*p*= .033) and over liquid codas (*p*=.042), although not over /s/ coda.

Similarly, the production of acoustic diphthongization is favoured by obstruent codas (26%), followed by nasal codas (19%), liquids (5%) and finally /s/ (3%), in that order. A post hoc test revealed highly significant differences between nasal and liquid codas (*p*= .010), liquid and obstruent codas (*p*= <.001), /s/ and obstruent codas (*p*= <.001) and nasal and /s/ codas (*p*= <.001) for acoustic diphthongization.

The results for coalescence show a higher percentage of occurrences when the vowel sequence is followed by a liquid coda (60%), and the lowest percentage with obstruent codas (45%). However, none of these differences revealed to be significant. On the contrary, different deletion rates show rather significant results: the highest percentage of its occurrence is with /s/ coda (39%), whereas the lowest percentage is with obstruent codas (18%). The pairwise comparison test reveals a significant difference between these two groups (*p*= .014).

Following the procedures in the previous section (section 3.2.5) for coda type effects, codas were grouped into sonorants and obstruents. Table 35 displays the results of their effects.

Table 35
Sonorants versus obstruents: percentage of strategies under effect of coda type

Strategy	Sonorant	N	Obstruent	N	*p*-value	F-value
Hiatus	3%	249	7%	208	.046*	F(1,455)= 3.989
Ac. diph.	13%	249	13%	208	.812	F(1,455)= .057
Coal.	55%	249	51%	208	.388	F(1,455)= .748
Del.	29%	249	30%	208	.835	F(1,455)= .043

The only significant difference was revealed for hiatus that, confirming the results from table 34, shows a higher percentage of occurrences with obstruent codas (7%). Table 36 shows the results of a similar analysis to that in table 35, in which tokens with the /s/ coda were excluded. Hiatus and acoustic diphthongization shows a significantly higher percentage of occurrences followed by non-sibilant obstruent codas (11% and 26% respectively), whereas coalescence and deletion shows the opposite result (45% and 18%). Thus, the results show various significant differences for all cases except for coalescence.

Table 36
Sonorants versus non-sibilant obstruents: percentage of strategies under effect of coda type

Strategy	Sonorant	N	Obstruent	N	*p*-value	F-value
Hiatus	3%	249	11%	89	.002*	F(1,336)= 9.972
Ac. diph.	13%	249	26%	89	.006*	F(1,336)= 7.643
Coal.	55%	249	45%	89	.103	F(1,336)= 2.674
Del.	29%	249	18%	89	.044*	F(1,336)= 4.099

Results on coda type suggest that hiatus and acoustic diphthongization are favoured in vowel sequences with obstruent codas, whereas coalescence and deletion show the lowest percentage of occurrences in that context. Post-hoc tests have confirmed this result. Added to that, deletion shows the highest percentage of occurrence when the vowel sequence is followed by a /s/ coda.

Figure 16 summarizes the possibility of coda effect on hiatus resolution strategies:

Figure 16
Effects of coda type on hiatus and hiatus resolution strategies

	/s/	nasal	liquid	obstruent
Hiatus	*no*	*yes*	*yes*	*yes*
Acoustic diph.	*no*	*yes*	*yes*	*yes*
Gliding	*no*	*no*	*no*	*no*
Coalescence	*yes*	*no*	*no*	*no*
Deletion	*yes*	*no*	*no*	*no*

3.3.6. Summary

The overall results on hiatus resolution strategies, confirm the following trends so far:

a) Hiatus is rather maintained when the VV-sequence contains the low vowel /a/ in V1 position and a mid back vowel in V2 position. On the contrary, it tends to resolve when the vowel sequence has a back vowel /o/ in V1 position and a low vowel /a/ in V2 position. If hiatus resolution targets V1 more often, then HYPOTHESIS I is partly confirmed, being vowel /a/ in V1 position the most sonorous and longest of the vowels. But no significant results are obtained for vowel /e/ that can completely confirm HYPOTHESIS I. Thus, further analysis on vowel position and quality in the next section may reveal other information.

b) Within word boundaries hiatus and acoustic diphthongization occur more often than coalescence and deletion, which are preferred across word boundaries. These results confirm HYPOTHESIS II.

c) Across word boundaries, results seem to partly confirm HYPOTHESIS III, since hiatus and acoustic diphthongization are the preferred strategies for content+function combinations, that is, hiatus is maintained. On the contrary to the expectations, in content+content combinations vowel sequences resolve hiatus through coalescence and deletion mostly. Finally, no significant results are drawn for function+content combinations, except that they do not show to maintain hiatus over the other combinations of word types. This also suggests to be in the lines of HYPOTHESIS III.

d) Comparing vowel sequences with and without a coda, results show greater percentages of hiatus and acoustic diphthongization for codaless vowel sequences, and more hiatus resolution when the sequence has a coda. These results run contrary to HYPOTHESIS IV.

e) Finally, regarding coda type, HYPOTHESIS V is also confirmed. The results show higher percentages of hiatus and acoustic diphthongization for vowel sequences followed by an obstruent coda (excluding /s/), while as sonority increases, hiatus resolution strategies (coalescence and deletion) take place. Deletion shows the greatest percentages of occurrence for the /s/ coda.

The overall results provided in this section are partial. After analyzing duration and formant frequency changes of the vowel sequences and considering whether hiatus or a strategy to resolve it has taken place, a number of significant trends are suggested. But in order to arrive to more relevant conclusions, the role of the target vowel within the sequence must be analyzed. After that, all the results are discussed together in section 3.5.

3.4. V1 as the target vowel

The next step in the analysis of the production results was to investigate the effect of the various segmental and prosodic factors from section 2.1 on V1 position as the target for hiatus resolution. The established idea in the literature is that hiatus resolution preferably targets V1 crosslinguistically (Casali 1997). Thus, based on the different hiatus resolution strategies that resulted from the production task, for every instance of hiatus resolution whether V1 or V2 was the target vowel was recorded for each speaker. This section reports the percentages of V1 targeting in hiatus resolution cases. The goal is to confirm or dismiss that V1 targeting is more common under the factors presented in section 2.1. Only acoustic diphthongization and deletion are reported in this section, however, since hiatus does not affect any of the vowels and coalescence affects both. Added to that, gliding has been omitted due to the limited scope of analysis that it presents (refer to section 3.1). Once more, the results are reported in the order of previous sections in this chapter, following the presentation of the independent factors under study.

3.4.1. Effects of vowel position and quality on V1 targeting

The question that needs to be answered is to what extent changing the quality of the vowels in the sequence actually does have an effect on the resolution of hiatus, and how is the vowel in V1 position modified (targeted). In order to resolve this question and following previous sections from this chapter, a first block of analyses is run focusing on vowels in V1 position, then V2 position.

Table 37 below reports the results from the analysis run on the percentage of V1 targeting, under the effect of vowel position and quality of V1. The results show the highest percentage of V1 targeting for both acoustic diphthongization and deletion when V1 is the vowel /e/ (74% and 87% respectively), followed by the vowel /o/ (58% and 49%) and finally /a/ (49% and 40%) in that order. The statistical differences are significant. A pairwise comparison with a Scheffe post-hoc test for multiple comparisons reveals a significant difference (i) between /e/ and /a/ for acoustic diphthongization ($p = .016$) and deletion ($p < .001$) and (ii) between /e/ and /o/ for deletion ($p < .001$), although not for acoustic diphthongization.

Table 37
Percentage of V1 target under effect of V1 quality

Strategy	V1=/a/	N	V1=/e/	N	V1=/o/	N	*p*-value	F-value
Ac. diph	49%	55	74%	73	58%	55	.013*	F(2,180)= 4.463
Deletion	40%	85	87%	76	49%	89	<.001*	F(2,247)= 23.397

A second set of analyses was run grouping vowels in terms of vocalic features (height, frontness and backness). Table 38 below shows the results of the first of these analyses, the percentage of V1 target under the effect of V1 height.

Table 38
Percentage of V1 target under effect of V1 height

Strategy	V1=low	N	V1=mid	N	*p*-value	F-value
Ac. diph	49%	55	67%	128	.021*	F(1,181)= 5.434
Deletion	40%	85	67%	165	<.001*	F(1,248)= 17.337

According to the results in table 38, V1 is targeted more often if it is a mid vowel both in acoustic diphthongization (67%) and deletion (67%). The differences for both strategies show significant results. These results seem to agree with those in the previous table, considering that vowel /e/ is a mid vowel.

Concerning the frontness of the vowels in the sequence, the results displayed in table 39 are consistent with those in the preceding table, in that a greater percentage of V1 target occurs in both strategies when V1 is a front vowel (acoustic diphthongization 74% and deletion 87%). Once again, these results show to align to those in the previous two tables.

Table 39
Percentage of V1 target under effect of V1 frontness

Strategy	V1=front	N	V1=non-front	N	*p*-value	F-value
Ac. diph	74%	73	54%	110	.005*	F(1,181)= .229
Deletion	87%	174	45%	174	<.001*	F(1,248)= .209

Table 40 displays the results under the effect of backness of V1, which show a preference for non-back vowel. However, no significant differences were obtained in this analysis.

Table 40
Percentage of V1 target under effect of V1 backness

Strategy	V1=back	N	V1=non-back	N	*p*-value	F-value
Ac. diph	58%	55	63%	128	.518	F(1,181)= .420
Deletion	49%	89	62%	161	.052	F(1,248)= 3.797

The results in table 40, although not significant, go along the results in the previous tables. There is a greater chance for V1 to be targeted for both strategies of hiatus resolution when V1 is the vowel /e/; on the contrary, fewer chances occur when V1 is the vowel /a/.

Turning now to the effects of the nature of the vowel in V2 position, Table 41 displays the results obtained from a first analysis. Acoustic diphthongization targets V1 more often if V2 is the vowel /a/ (78%), then the vowel /o/ (60%) and finally the vowel /e/ (41%), in that order of preference. Deletion, on the other hand, does not show a preference between vowels /a/ and /o/, but shows the lowest percentage of V1 targeting when V2 is the vowel /e/ (14%). In other words, both strategies prefer to target vowel /e/ regardless of its position. The difference in the results of both strategies revealed to be significant.

Table 41
Percentage of V1 target under effect of V2 quality

Strategy	V2=/a/	N	V2=/e/	N	V2=/o/	N	*p*-value	F-value
Ac. diph	78%	51	41%	32	60%	100	.002*	F(2,189)= 6.420
Deletion	76%	103	14%	73	76%	74	<.001*	F(2,247)= 59.592

The pairwise comparison with a Scheffe post-hoc test for multiple comparisons run on these results confirm the significant difference of the effects of vowel /e/ over the others: for acoustic diphthongization, the difference is between /e/ and /a/ (p= .002) and in deletion between /e/ and /a/ (p< .001) and /e/ and /o/(p< .001).

The results of a close analysis to the vocalic features of height, frontness and backness are reported next. Table 42 displays the percentages of V1 target under V2 height. For both strategies (acoustic diphthongization and deletion), V1 is targeted more often when V2 is a low vowel (acoustic diphthongization 78% and deletion 76%), a result that coincides with those displayed in table 41 for vowel /a/. The lower percentage of V1 target when V2 is a mid vowel indicates, once again, that mid vowels are preferred targets regardless of their position in the vowel sequence. The differences for both strategies revealed to be significant.

Table 42
Percentage of V1 target under effect of V2 height

Strategy	V2=low	N	V2=mid	N	*p*-value	F-value
Ac. diph	78%	51	55%	132	.004*	F(1,181)= 8.633
Deletion	76%	103	45%	147	<.001*	F(1,248)= 25.817

Table 43 below shows significant results based on frontness for both strategies. It shows once again a consistency with the previous tables (tables 37 and 39) on vowel quality. The lower percentage of V1 targeting (acoustic diphthongization 41% and deletion 14%) in the case of both strategies when V2 is a front vowel implies that the percentage of front vowel targets are always higher, regardless of the position of the front vowel.

Table 43
Percentage of V1 target under effect of V2 frontness

Strategy	V2=front	N	V2=non-front	N	*p*-value	F-value
Ac. diph	41%	32	66%	151	.007*	F(1,81)= 7.548
Deletion	14%	73	76%	177	<.001*	F(1,248)= 119.666

Finally, table 44 below, showing the effect of backness on V2, displays a highly significant result only for deletion: a higher percentage of V1 target occurs when V2 is a back vowel (76%). This implies that deletion will target non-back vowels more often than back vowels. The results on acoustic diphthongization show the opposite tendency, a higher percentage of V1 target when V2 is a non-back vowel (64%). However, this difference did not reveal to be significant.

Table 44
Percentage of V1 target under effect of V2 backness

Strategy	V2=back	N	V2=non-back	N	*p*-value	F-value
Ac. diph	60%	100	64%	83	.596	F(1,81)= .283
Deletion	76%	74	50%	176	<.001*	F(1,248)= 14.781

The results on the effect of vowel position and quality on the percentage of V1 target have shown that position and vowel quality have an effect on each other, but they are suggested to have separate effects on hiatus resolution. Strategies of hiatus resolution have shown to target mid front vowel /e/ more often, regardless of its position in the sequence. All other factors do not have an effect on the choice of V1 targeting.

3.4.2. Effects of word boundaries on V1 targeting

When the vowels sequence appears at the word limits, as in *casa enorme*, hiatus resolution targets V1 or V2 more often? And which position is targeted if the vowel sequence appears within the word limits, as in *paellera* (cf. table 2 for the complete set of cases in study)? The answer about the effect of word boundaries in V1 targeting when hiatus resolution occurs is presented next, in table 45.

Table 45
Percentage of V1 target under effect of word boundaries

Strategy	Within	N	Across	N	*p*-value	F-value
Ac. diph	48%	52	67%	131	.016*	$F(1,181)= 5.870$
Deletion	0%	11	60%	239	<.001*	$F(1,248)= 16.540$

The results displayed in the table show that both strategies show a significant higher percentage of V1 targeting across word boundaries.

3.4.3. Effects of word type on V1 targeting

Moving on to word type (cf. section 2.1.2.3), the results of the statistical analysis run on the effect of word type are displayed in table 46. On the one hand, acoustic diphthongization shows the lowest percentage of V1 target in content+function words; but equal percentages of V1 target for content+content and function+content words. Deletion, on the other hand, shows the highest percentage of V1 target in content+function words; whereas the lowest percentage occurs in content+content combinations.

Table 46
Percentage of V1 target under effect of word type

Strategy	Cont.+cont	N	Func.+cont.	N	Cont.+func.	N	*p*-value	F-value
Ac. diph	68%	79	68%	25	63%	27	.874	F(2,128)= .135
Deletion	58%	183	63%	35	76%	21	.256	F(2,236)= 1.369

However, none of these differences revealed to be significant, nor the results of the Scheffe post-hoc test for multiple comparisons. Thus, no significant conclusions can be drawn from the analysis on word type.

3.4.4. Effects of syllable type on V1 targeting

The results on the effects of syllable type (cf. section 2.1.2.4) are displayed in Table 47. Both strategies show a higher percentage of V1 target when the vowel sequence is followed by a coda.

Table 47
Percentage of V1 target under effect of syllable type

Strategy	Coda	N	No coda	N	*p*-value	F-value
Ac. diph	64%	58	61%	125	.700	F(1,181)= .149
Deletion	60%	134	55%	116	.472	F(1,248)= .519

But the differences in this analysis did not show to be significant. Thus, as in the previous section, no significant conclusions can be drawn with respect to effects of syllable type.

3.4.5. Effects of coda type on V1 targeting

Finally, regarding coda type (cf. section 2.1.2.5), a first analysis was run, to verify the effects of each of the possible codas on the percentage of V1 target. The results are displayed in table 48 below.

Table 48
Percentage of V1 target under effect of coda type

Strategy	Nasal	N	Liquid	N	/s/	N	Obstruent	N	*p*-value	F-value
Ac. diph	81%	27	33%	6	33%	3	55%	22	.042*	F(3,54)= 2.916
Deletion	49%	37	71%	35	52%	46	81%	16	.044*	F(3,130)= 2.770

On the one hand, acoustic diphthongization shows the highest percentage of V1 targeting occurrences with nasal codas, followed by obstruent codas. The lowest percentage of V1 target is given when the coda is a liquid or a /s/. Deletion, on the other hand, shows the highest percentage of V1 targeting with obstruent codas, followed by liquids, then /s/ and finally nasals, in that order. There is a revealing trend concerning nasal codas, which show a greater percentage of V1 target when acoustic diphthongization takes place, but the lowest percentage when deletion takes place. These differences revealed to be significant. However, a pairwise comparison with a Scheffe post-hoc test for multiple comparisons run on these results did not show any significance that could reveal more accurate differences among the coda groups.

Thus, in order to look for more accurate results on the effects of the various codas, a second set of analyses was run pulling codas together as, following the analyses in the previous sections: sonorants versus obstruents. Table 49 displays the results of the first analysis. On the one hand, acoustic diphthongization favours V1 targeting in vowel sequences followed by a sonorant coda, a result which is partly consistent with the one in table 48 on nasal codas. On the other hand, deletion does not provide any revealing results, showing equal percentages for both groups.

Table 49
Sonorants versus obstruents: percentage of V1 target under effect of coda type

Strategy	Sonorant	N	Obstruent	N	*p*-value	F-value
Ac. diph	73%	33	52%	25	.107	F(1,56)= 2.677
Deletion	60%	72	60%	62	.996	F(1,132)= .000

None of the results in table 49 are significant, nor were they in the post-hoc test, even though the analysis in table 48 above shows a high significance for the overall results. Added to that, for acoustic diphthongization, two groups have the same percentage (33%) in table 48 (liquid and /s/ codas). Moreover, nasals and /s/ show very close results (49% and 52% respectively) for deletion. Thus, a second analysis was run excluding /s/ coda from the obstruent group and the results are displayed in table 50 next.

Table 50
Sonorants versus non-sibilant obstruents: percentage of V1 target under effect of coda type

Strategy	Sonorant	N	Obstruent	N	*p*-value	F-value
Ac. diph	73%	33	55%	22	.171	F(1,53)= 1.927
Deletion	60%	72	81%	16	.108	F(1,86)= 2.641

The results in table 50 show a higher percentage of V1 target under the effect of sonorant codas for acoustic diphthongization, but in the obstruent group for deletion. Both of these results show consistency with those reported in table 48. However, none of these results were statistically significant and, thus, no conclusions could be made about the effect of coda type on V1 targeting.

3.4.6. Summary

The results on the effect of the various factors on the percentage of V1 target when hiatus resolution applies are summarized below[15]. These results show trends that do not confirm or dismiss the different hypotheses proposed for the production experiment. But they do reveal information that is indirectly related to them. Further discussion on these results is needed in order to understand them, and this is provided in section 3.5.

a) In terms of the position and nature of the vowels involved in the sequence, the analyses displayed in this section show a greater preference to target V1, both in acoustic diphthongization and deletion, when V1 is the front mid vowel /e/ and the lowest preference when vowel /a/ is in V1 position. Regarding V2 position, V1 is still more often targeted when V2 is the vowel /a/, and least when V2 is the vowel /e/. These results imply that vowel /e/ is the preferred target for hiatus resolution, regardless of its position in the sequence. This conclusion runs contrary to HYPOTHESIS I, which stated that hiatus resolution is likely to affect vowels in V1 position more than vowels in V2 position, regardless of their quality.

b) Word boundaries: highly significant preference is observed for V1 target across word boundaries.

c) No significant results were obtained across word boundaries, but a trend is suggested regarding content+function word combinations: while acoustic diphthongization hardly targets V1 in content+function combinations, when deletion occurs, it is that contexts that V1 is targeted most. All other results concerning the other word type combinations do not reveal any trends.

d) The analysis on syllable type shows for both strategies a preference for V1 targeting in vowel sequences with a coda. This difference is not significant, but suggests a trend that may be running contrary to HYPOTHESIS IV.

e) Finally the analyses on coda type show no significant results overall, but a trend is suggested for nasals and obstruents. When acoustic diphthongization takes place,

[15] Nothing is said yet about results concerning HYPOTHESIS I, though. In order to confirm or dismiss that hypothesis, all the results from sections 3.2, 3.3 and 3.4 are interpreted and reported in section 3.5.

greater number of V1 target occurs when the coda is a nasal and less when the coda is a /s/. In deletion cases, V1 target shows a greater percentage as well when the coda is an obstruent. If V1 target is more common overall, it may suppose less informational loss when hiatus resolution takes place. If that is so and obstruent codas prefer to maintain hiatus (HYPOTHESIS V), then it may follow that the results on obstruents in this section run along the expected results. The opposite may be true for nasal codas. A further analysis is left for the next section.

The following chart serves to summarize in a more graphical way the significant results obtained in this section. The chart shows those contexts that have an effect on the decision of targeting V1 when hiatus resolution occurs.

Figure 17
Preference for V1 targeting in hiatus resolution contexts

Effect of...	*Preference for V1 target*
1. Vowel position and quality	If V1 is vowel /e/
2. Word boundaries	Across word boundaries
3. Word type	No
4. Syllable type	If coda
5. Coda type	no

3.5. Summary of the results on production

This section wraps up the results obtained throughout this chapter from the analyses of the four dependant variables (duration, formant frequency, strategies of hiatus resolution and target vowel) in order to confirm or dismiss the hypotheses proposed in chapter 2 about the production of VV-sequence and hiatus resolution.

Concerning vowel position and quality, the analyses run on duration revealed a number of results that were not statistically significant for the most part. However, they strongly suggested that front vowels produce shorter vowel sequences regardless of their position in the sequence. When the mid front vowel /e/ is V1 or V2 position, the VV-sequence has shorter duration (tables 9 through 12); longer, on the contrary, when V1 or V2 is a low vowel /a/ or a back vowel /o/ (tables 13 through 16).

The trend on durational variability of vowel /e/ is confirmed partially through the results on the percentage of occurrence of the different strategies, which revealed to be significant, if longer duration implies more chances to maintain hiatus and fewer chances to resolve it through different strategies. Results show that, for V1 position, there is a gradation running from more to fewer chances to maintain hiatus that affects vowel /a/, then vowel /e/ and finally vowel /o/; that is, hiatus is maintained more often if V1 is an /a/, less if it is an /e/ and resolution and especially deletion occurs if V1 is the vowel /o/ (tables 23 through 26). Added to that, for V2 position, a similar gradation is found, therefore more chances of maintaining hiatus when V2 is the vowel /o/, less when it is the vowel /a/ and more hiatus resolution, especially deletion, takes place when V2 is the vowel /e/ (tables 27 through 30). These results, thus, confirm that hiatus resolution has definitely more chances to occur for the front vowel /e/, which produces shorter vowel sequences, regardless of its position. Moreover, hiatus is maintained more often if V1 is the vowel /a/ and V2 is the vowel /o/. Both of these vowels produce longer VV-sequences.

The analyses on V1 target further confirm the effect of the vowel /e/ on hiatus resolution. Vowel /e/ is a preferred target in V1 position when hiatus resolution takes place (tables 37 through 40), this result being significant. But vowel /e/ is also suggested to be a better target in V2 position, since a smaller percentage of hiatus resolution targets V1 when V2 is a low or a back vowel (tables 41 through 44). In sum, vowel /e/ results in the best target for hiatus resolution regardless of its position in the vowel sequence. This conclusion fails to confirm HYPOTHESIS I, which stated that V1 is more often targeted in hiatus resolution contexts. Instead, the results suggest that vowel quality has a greater effect than vowel position in hiatus resolution, or so it is the case for vowel /e/ in Spanish.

This claim does not follow for all strategies, though. If vowel /e/ produces the shortest vowel sequences and is the most preferred target among the three vowels for hiatus resolution, then deletion of the vowel /e/ should show a greater percentage of occurrences. This is only the case when V2 is the vowel /a/. The results obtained from the analyses on strategies show a further significant result: deletion is most common when V1 is the vowel /o/; the results from the analyses on strategies revealed this to be highly significant and the results on the back vowel were reinforced after a post-hoc test.

Two more relevant results were obtained in the analysis on strategies based on vowel position and quality. First, when V2 is a back vowel, both hiatus and acoustic diphthongization shows the greatest percentage of occurrence, whereas coalescence and deletion show the lowest. This result is indeed relevant since it suggests a partition among the various strategies of hiatus resolution into two main groups; i.e. hiatus and acoustic diphthongization, containing two vowels in the sequence, and coalescence and deletion, which result in a single vowel. The effect of the back feature is still to be studied, since no further results were obtained concerning that vowel or its relation to the V2 position. Secondly, coalescence shows the highest percentage of occurrence when V2 was the vowel /a/. This is an interesting result suggesting that centralization of the vowel sequence (for vowel /a/ is a low central vowel) is preferred in raising sonority sequences (/ea/ and /oa/) than in falling sonority sequences (/ao/ and /ae/).

The overall results just described run contrary to HYPOTHESIS I, since vowel quality does have an effect on hiatus resolution, greater than vowel position. However, it is not exactly true that more sonorous or more marked vowels resist better hiatus resolution, as Working HYPOTHESIS II would propose (cf. section 2.1.2.1). Furthermore, the effects of vowel quality over vowel position have only been confirmed for vowel /e/, but for vowels /a/ and /o/ no significant conclusion were obtained.

The results of the analyses based on word boundaries were highly significant for the most part. Vowel sequences are longer within word boundaries than across word boundaries (table 17). Furthermore, hiatus and acoustic diphthongization (and gliding) occur more often within word boundaries; whereas more extreme forms of hiatus resolution such as coalescence and deletion (which require monophthongization, and this implies a durational reduction) occur more across word boundaries (tables 31). HYPOTHESIS II, which stated that hiatus resolution applies more often across word boundaries, is thus confirmed. Added to that, the analysis on V1 target supports that V1 is a more common target across word boundaries (table 45). If hiatus resolution affects more often the first vowel of the sequence crosslinguistically (Casali 1997), then the conclusions from the production experiment run along that claim too.

The analyses on word type did not reveal any general significant results, only a trend is suggested. Concerning duration, vowel sequences in content+content words show significantly shorter duration than those in other word combinations, but no distinctions are done between function+content and content+function (table 18). Regarding strategies, content+content combinations show the highest percentage of coalescence and deletion instances, although this result is not significant (table 32). With respect to V1 target, no further information is obtained concerning the effect of word type on hiatus resolution, except the suggestion of a trend along the lines of the previous results: a greater percentage of V1 target for acoustic diphthongization of vv-sequences of content+content and function+content words is found, whereas a greater percentage of V1 target for deletion in content+function combinations (table 46). The overall results fail to confirm HYPOTHESIS III, which stated that vowel sequences in function+content word combinations would show more hiatus resolution than function+content; this, in turn, more than content+content. In fact, the contrary is true: content+content contexts favour more extreme forms of hiatus resolution (coalescence and deletion).

On the subject of the effect of codas on hiatus resolution, the analyses revealed a robust result: vowel sequences with a coda were significantly shorter than codaless vowel sequences (table 19). Added to that, sequences with a coda in hiatus resolve preferably via coalescence and deletion, whereas codaless sequences maintain hiatus or resolve it via acoustic diphthongization more often (table 33). With regard to V1 target, no significant information was obtained from the analysis. The results show that V1 is more often targeted in vv-sequences with a coda; but this is not enough information to suggest that actually more hiatus resolution may occur in sequences with a coda. However, the results from durational variability and hiatus resolution strategies are significant. They run contrary to HYPOTHESIS IV, which stated that vowel sequences with a coda are more resistant to hiatus resolution. The results have shown that, in fact, vowel sequences with a coda are better candidates for hiatus resolution, especially through more extreme strategies such as coalescence or deletion.

Now, for those vv-sequences with a coda, the effect of the coda type did not reveal overall significant results, but an interesting trend is observed. In terms of duration, obstruent codas provide longer vowel sequences, this result being significant (tables 20 through 22). Added to that, obstruent codas maintain hiatus or resolve via acoustic diphthongization more often than sonorant codas or /s/ (this result is also significant); moreover, deletion is the preferred strategy to resolve vowel sequences with a /s/ coda (tables 34 through 36). Finally, regarding V1 target, no significant results were obtained from the analysis, but a number of considerations are noted down: for acoustic diphthongization, V1 target show a greater percentage in nasal codas, less in /s/ coda; for deletion, a greater percentage of V1 target appears in obstruent codas. The overall results concerning coda type partly confirm HYPOTHESIS V. HYPOTHESIS V(a) stated that obstruent codas would produce longer sequences and the results have supported significantly this statement. On the contrary, HYPOTHESIS V(b) suggested that, as opposed to obstruent codas, nasals and liquids would show more durational reduction as well as more chances for hiatus resolution to occur. But no significant results were obtained in any case. Finally, HYPOTHESIS V(c), which stated that under the effect of a /s/ coda vowel sequences would reduce and resolve hiatus, is also confirmed. Deletion, in fact, is the preferred strategy under the effect of a /s/ coda.

The following chart provides a visual summary of the significant results obtained throughout this chapter, which were discussed in this section.

Figure 18
Summary of the significant results about the effects of 5 phonological factors on vowel sequences

Factors	**Durational reduction**	**Hiatus resolution**	**Prefer V1 target**
1. Vowel quality	+ if vowel /e/	+ if vowel /e/	Vowel /e/ always, regardless of position
2. Word boundaries	+ across w.b. - within w.b.	+ across w.b. - within w.b.	yes
3. Word type	+ if content+content	+ if content+content	---
4. Syllable type	+ if sequence with coda	+ if sequence with coda (coalescence and deletion)	yes
5. Coda type	+ if /s/ coda - if obstruent coda	+if /s/ coda (deletion) - if obstruent coda	yes

CHAPTER 4

THE STRATEGY OF DELETION: FOCUS ON A LEXICAL DECISION EXPERIMENT

4.1. Introduction

The production experiment described in chapters 2 and 3 is complemented by another experiment performed by the same subjects (cf. section 2.2.1). It is a lexical decision experiment that tests the subjects' intuitions on the possibility of having deletion as a strategy of hiatus resolution. Deletion is the most radical strategy of hiatus resolution, in the sense that it implies a durational reduction from two vowels to one and it requires the realization of a single vowel out of the two vowel from the original sequence; unlike in coalescence, which also shows a single vowel, but that vowel contains traces of both original vowels in the sequence (cf. section 1.4.2). This experiment was designed in order to study intuitions of native subjects on deletion. The same factors analyzed throughout chapters 2 and 3 (i.e. vowel position and quality, word boundaries, word type, syllable type and coda type) have been used.

Previous studies on deletion of vowel sequences suggest a preference for V1 deletion resulting from the effect of a number of segmental and prosodic factors such as word boundaries, stress or syllable type (review section 1.4). Casali (1997) claims, however, that V2 deletion can also occur under specific circumstances. The motivation to carry out a lexical decision experiment is the observation that in cases where hiatus is resolved via deletion, listeners seem to have more or less difficulties to retrieve the information, depending on the vowel quality and its position in the vowel sequence. For instance, given the word pairs in examples (28) through (30) below to two native subjects of Spanish working at the phonetics laboratory where these study was developed, both speakers agreed that the forms with V2 deletion seem possible phonetic representations of the vowel sequences, whereas V1 deletion simply “sounded awkward” (this has been marked with an asterisk).

(28)	*casa enana*	[ˈka.sa # e.ˈna.na]	‘tiny house’
	V1 deletion:	* [ˌka.se.ˈna.na]	
	V2 deletion:	[ˌka.sa.ˈna.na]	
(29)	*esfuerzo enorme*	[es.ˈfwer.θo # e.ˈnor.me]	‘huge effort’
	V1 deletion:	* [es.ˌfwer.θe.ˈnor.me]	
	V2 deletion:	[es.ˌfwer.θo.ˈnor.me]	
(30)	*ninguna oferta*	[nin.ˈgu.na # o.ˈfer.ta]	‘no offer’
	V1 deletion:	* [nin.ˌgu.no.ˈfer.ta]	
	V2 deletion:	[nin.ˌgu.na.ˈfer.ta]	

Native speakers seem to have clear intuitions for other similar examples on which is the preferred target vowel for deletion. This decision may be influenced not only by vowel quality, but also by the contexts in which the vowel sequences appear. Thus, the objective of the lexical decision experiment is to gain knowledge on the intuitions of native speakers regarding deletion as a strategy of hiatus resolution. This study contributes to defining the factors that affect V1 and V2 deletion.

Right after each subject executed the reading task for the production experiment (cf. section 2.2.2) they were ask to perform a lexical decision task. During its development, subjects were provided with sound stimuli made up of Spanish words originally containing hiatus, but to which one of the vowels in the sequence had been removed. Subjects were asked to judge the sound inputs as correct or incorrect Spanish. The answers they gave as well as their reaction time (i.e. the time from the end of the listened input to the execution of the answer) were recorded for posterior analysis. The object of the present chapter is to describe the experimental design and to analyze the results of this lexical decision experiment.

4.2. Methodology and experimental design

In order to maintain the coherence of the study in this dissertation, the corpus for the lexical decision experiment was designed under the control factors and independent variables proposed in chapter 2 (cf. sections 2.1.1 and 2.1.2. respectively), listed here again, as follows:

a) Word position and quality: combinations of vowels /a, e, o/ in V1 and V2 positions.
b) Word boundaries: within words or across word boundaries.
c) Word type: function or content words.
d) Syllable type: vowel sequences with or without a coda.
e) Coda type: nasal, liquid, /s/ or obstruent coda.

4.2.1. Hypotheses about deletion contexts

Deletion, as the most extreme form of hiatus resolution, involves complete loss of one of the vowel segments. Judging a phonetic input as correct indicates that the listener is able to recover all the relevant information for lexical retrieval, even though deletion has occurred. Overall, it is expected that subjects will judge as correct a listened phonetic input in which deletion does not affect information recovering, no matter the effect of the specific factors acting on the phonetic input at the moment a subject listens to it. Therefore, results will show a higher percentage of answers judged as correct in contexts in which deletion is likely to happen and a lower percentage of acceptance in contexts were deletion is unlikely to occur. Likewise, reaction time values will be expected to be shorter when deletion occurs in contexts that favor deletion. In instances of phonetic inputs judged as correct, shorter reaction times will reflect subjects' less hesitation in the judgment, whereas longer reaction times will reflect more hesitation, they may be suggesting the subjects' uncertainty for allowing deletion in a given phonetic input (refer to section 4.2.4.2 for a description on the methodology of reaction time measurements).

The results in this experiment aim at contributing to the generalizations made in this dissertation about the effects of various segmental and prosodic factors on deletion, within the general study of the factors affecting hiatus resolution. This section defines the hypotheses that are expected in the analysis of the results of the lexical decision experiment. The research question in this experiment is twofold: (i) whether deletion is well accepted in the different contexts based on the independent factors (what factors favor the perception of deletion as correct); and (ii) whether there is a correspondence between judgments of correct responses and the reaction time needed to answer the lexical decision task.

4.2.1.1. Vowel position and quality

With regard to vowel position and vowel quality within the vowel sequence, the literature claims that hiatus resolution targets V1 more than V2 (cf. section 1.4). Therefore, we should expect the same for deletion, as it is a strategy of hiatus resolution. This means that answers for phonetic inputs with V1 deletion should show a greater percentage of acceptance and shorter reaction times. If that is so, then the quality of the vowels involved in the process of deletion should not be expected to affect the choice of deletion to target one vowel or the other (refer to section 2.1.2.1 for a further explanation on the effects of vowel quality and position in each other). For that matter, hypothesis VI is formulated under (31). It is the first hypothesis concerning the effects of vowel position on the acceptance of vowel sequences with deletion:

(31) *Hypothesis VI for vowel sequences undergoing deletion*

Subjects judge as correct deletion of V1 more often than deletion of V2 and reaction times for V1 deletion will be shorter than for V2 deletion, all regardless of the quality of the vowels involved.

4.2.1.2. Word boundaries

The Initiality Condition discussed in section 1.3 stated that initial elements are relevant for information retrieval and, thus, show preference for hiatus in word-initial positions (Hualde & Chitoran 2003). The Initiality Condition makes the vowel sequence resolve in a way that minimum information is lost. Along these lines, word initial vowels are longer than word final ones (Casali 1997). It follows from this statement that word initial vowel sequences are also longer than vowel sequences across word boundaries and therefore hiatus may be preserved more often in vowel sequences within word boundaries (cf. table 2). Deletion, therefore, as a strategy of hiatus resolution, should be expected to occur more often across word boundaries. Based on this motivation, hypothesis VII is stated in (32).

(32) *Hypothesis VII for vowel sequences undergoing deletion*

Subjects judge as correct deletion across word boundaries more often than deletion within word boundaries and their reaction times for deletion across word boundaries are shorter than for deletion within word boundaries.

4.2.1.3. Word type

Greater acceptance of deletion is also hypothesized to depend on the word type. Lexical words are usually more resistant to phonetic or phonological changes. It is preferable to maintain the segments that contain lexical information, since non-lexical words (function words) are a close group and the information retrieval of these phonetic inputs is always easier than that of lexical ones, due to the fact that they are more predictable (cf. section 2.4.3). Based on the word combinations established in section 2.1.2.3 (content+content, function+content, and content+function), it can be predicted that in content+content word combinations (both words have lexical content that must be maintained) subjects will judge incorrect deletion more often than in other word combinations, which contain a function word. In word combinations containing a function word, the effect of carrying lexical content should only affect one of the vowels in the sequence: that vowel belonging to the content word.

In function+content word combinations, assuming that the word pair behaves like a phonological word (cf. 2.1.2.3), then similar expectations to those about vv-sequences within word boundaries are held: the vv-sequence appears at the initial syllable of the phonological word, and therefore shows also fewer chances to resolve hiatus. As a consequence it is expected that deletion too will be less accepted. On the contrary, in content+function word combinations deletion, as a strategy of hiatus resolution, will be expected to occur more often. Thus, the hypothesis under (33) is proposed about the effects of word type on deletion.

(33) *Hypothesis VIII for vowel sequences undergoing deletion*

a) Subjects judge as correct deletion of vowel sequences in content+function word combinations more often than in function+content word combinations. Reaction times are shorter in content+function word combinations than in function+content word combinations.

b) Subjects also judge as correct deletion of vowel sequences in function+content word combinations more often than in content+content word combinations. Reaction times are also shorter in function+content than in content+content word combinations.

4.2.1.4. Syllable type

Regarding the effect of the existence of a coda following the vowel sequence, it was predicted under HYPOTHESIS IV for hiatus resolution that vowel sequences with coda would be more resistant to hiatus resolution than codaless sequences (cf. section 2.1.2.4). Consequently, deletion in vowel sequences without a coda are expected to be judged as correct more often than in sequences with a coda. The following hypothesis is thus stated:

(34) *Hypothesis IX for vowel sequences undergoing deletion*

Subjects judge as correct deletion in vowel sequences without a coda more often than in vowel sequences with a coda. Reaction times are shorter in vowel sequences without a coda than in vowel sequences with a coda.

4.2.1.5. Coda type

If different codas provide more or less sonority contrast to the preceding vowel sequence (refer to section 2.4.5), the nature of the deleted vowel will depend on the relation between the vowel sequence and the following coda (i.e. Burzio's 2007 V-to-C interaction). This suggests that deletion of a vowel in a vowel sequence will be licensed depending on its implications with the following consonant, from a production and from a perception point of view. Assuming the sonority hierarchy in Hualde (2005), the greater the sonority distance between two segments, the greater the contrast between those two elements. Thus, in contexts of vowel sequences followed by a coda, the greater the sonority distance between the vowel sequence and the following coda consonant, the greater the contrast between those segments, and the easier the perception of those sounds is. In other words, it seems that greater sonority contrast between the vowel sequence and the coda consonant leads to fewer chances to misperception; therefore, more chances for hiatus resolution to occur. This idea leads to the following prediction: obstruent codas will show more hiatus than nasals and these, in turn, more than liquids. If deletion is the most radical form of hiatus resolution strategies, deletion is expected to be judged more correct when the sonority distance between the vowel sequence and the coda consonant is smaller. In terms of deletion instances and reaction time measurements, which is the purpose of the experiment in this chapter, the prediction in the lines above is reformulated under (35a) below.

Regarding the special status of /s/ in coda position (section 2.1.2.5), deletion of vowel sequences followed by a /s/ coda should be expected to be rather common. For that reason, subjects are expected to allow it. That should be translated as a high number of responses judged correct and short reaction times. This prediction is stated under (35b) below.

(35) *Hypothesis X for vowel sequences undergoing deletion*

a) Subjects judge as correct deletion in vowel sequences with an obstruent coda (excluding /s/) more often than with a nasal coda. Reaction times are shorter in vowel sequences with an obstruent coda (excluding /s/) than with a nasal coda.

b) Subjects judge as correct deletion in vowel sequences with a nasal coda more often than with a liquid coda. Reaction times are shorter in vowel sequences with a nasal coda than with a liquid coda.

c) Subjects judge as correct deletion in vowel sequences with a /s/ coda more often than with any other codas. Reaction times are shorter in vowel sequences with a /s/ coda than with any other codas.

4.2.2. Phonetic inputs in the lexical decision experiment

The tokens from table 2 (refer to section 2.1.3) were used to make up the corpus for the lexical decision task. For each token (recall there were a total of 43), two phonetic forms were created, henceforth *phonetic inputs*, each with one of the vowels in the sequence deleted. For instance, for the token *paellera* [p**ae**ʝeɾa], the phonetic inputs [p**e**ʝeɾa] with V1 deletion and [p**a**ʝeɾa] with V2 deletion were created. In all cases, the phonetic inputs are non-words in Spanish. The purpose of the experiment was to make subjects listen to these phonetic inputs and respond whether they heard correct Spanish words or not[16].

4.2.3. Data recording procedures

The author of the experiment, also a native speaker of a northern variety of Peninsular Spanish, had recorded herself ahead of time producing the phonetic inputs with V1 and V2 deletion (43 tokens x 2), plus 17 filler phonetic inputs containing (i) non-words and real words and (ii) word pairs with similar structures as the phonetic inputs of study. The total of 103 phonetic inputs were recorded one by one in isolation in the same sound treated room where the production experiment took place, at the phonetics laboratory of the University of Illinois at Urbana-Champaign. The recordings were made using the *Praat* software for speech analysis (Paul Boersma and David Weenink,

[16] For the complete set of phonetic inputs that make up the corpus for this experiment refer to Appendix B.

www.fon.hum.uva.nl/praat, version 4.6.20, 2007: sampling rate 44.100Hz).The sound files produced in the recording were entered in a computer program in order to fulfill the task.

Subjects were asked to carry out the lexical decision task, which was developed with the help of a computer inside the sound treated room. This was done using *E-Prime* software, a reaction-time software created by Psychology Software Tools (www.pstnet.com), right after the production experiment was completed. Facing the computer, subjects were asked to listen to the sound stimuli implemented through E-Prime. The phonetic inputs under investigation were randomly presented to each of the subjects, only once. Subjects listened to each of the stimuli and had to make a decision right after whether what they heard was correct Spanish or not. If they thought what they heard was correct they pressed the *j* key on the computer keyboard with their right hand; if they thought it was incorrect, they pressed the *f* key with their left hand. The choice of the *j* and *f* keys is not random. They are often used in lexical decision tasks using E-Prime due to the fact they are placed in the middle of the keyboard and they follow naturally the position of the right and left arm when a subject is placed in front of the computer. The correct and incorrect responses made by the subjects were recorded into the computer, as well as the reaction time from the listening to each sound stimulus until the pressing of any key. The lexical decision task lasted about 10 minutes for each subject, and was performed right after the production task by each subject.

Thus, the whole experiment lasted about 20 minutes for each participant. Subjects were not familiar with the tasks they had to perform prior to their actual participation and they were not given any information about the object of the study until their participation was completed. The reason to organize both tasks in a specific order (first the production task, then the lexical decision task) was to make sure that subjects did not recognize the topic of study until the end. The lexical decision task only included phonetic inputs under investigation in isolation, not contextualized. Having placed the lexical decision task first would have provided subjects with the possibility of recognizing the object of study. Such awareness could have had an effect on the subsequent production task, by making subjects aware of what they had to read and therefore performing the task in a less natural way. As in the production experiment, upon the completion of the lexical decision task, subjects were asked whether or not they had figured out what the experiment was about. Once again, none of them was able to reveal any information about neither the topic nor the object of the study or the procedures to reach the desired objective.

4.2.4. Description of the dependent variables

As stated in the lines above, the lexical decision task measured the judgments of what subjects considered correct responses, and also the time it took subjects to answer after they heard each sound stimulus. Thus, the dependent variables that were measured in this experiment are *judgment of responses* and *reaction time*.

4.2.4.1. Judgments of responses

For each instance of the phonetic inputs provided to the subjects as sound stimuli (cf. section 4.2.2), the computer software automatically recorded both the responses judged as correct (recorded by pressing the key *j*) and incorrect (recorded by pressing the key *f*). The E-Prime software made it possible to reflect all the answers in a *Microsoft Excel* spreadsheet for posterior analysis. Although all answers were recorded, only the responses judged as correct were of interest to the experiment, however. Recall from section 4.2.2 that tokens were transformed into phonetic inputs by deleting one of the vowels in the sequences, thus producing non-words in Spanish. Judging phonetic inputs as incorrect meant that the sound stimuli subjects were presented with were non-existent in Spanish, which is logical to assume, since they were all non-words. However, those stimuli that subjects judged as correct were indeed taken into account for the study since, even if they had a missing vowel, that is, they were non-words, subjects were yet able to recognize them as possible Spanish.

4.2.4.2. Reaction time

Reaction time (henceforth RT) refers to the duration elapsed from the final moment of the sound stimulus to the pressing of a computer key in the computer keyboard by the subjects of the experiment. RTs were automatically recorded when the subjects pressed the keyboard, via the *E-Prime* software. Only RTs of responses judged correct were considered for the posterior analysis. The results show a great variation in the subjects' RTs; they were faster or slower depending on the subjects' judgment of the phonetic inputs. Shorter RT values indicate a shorter period of hesitation before the answer, that is, a faster reaction to the sound stimuli. In other words, when subjects heard a sound stimulus they pressed either *j* or *f* depending on whether what they heard sounded correct Spanish or not to them. Regardless of which key they pressed, the faster they pressed that key after hearing the sound stimulus implies they were more confident as to what their answer was. Thus, shorter RT values appear.

4.3. Results

The results of the lexical decision experiment were automatically recorded in the computer with the *E-Prime* program that was used to develop the task. Judgments of correct and incorrect responses as well as reaction times of the responses were registered both for V1 and V2 positions. After dismissing outliers (over 2,000 ms), valid RT values selected for the analyses were defined on the following premises: (a) only RT values of correct responses were used (cf. section 4.1.4.2) and (b) within this group, negative values were also included. A negative RT in this experiment reflects the subject's judgment (pressing of the key) before the sound input was completed. This act suggests that the subjects were able to judge (whether as correct or incorrect Spanish) the sound stimuli they were provided, even before they had heard the complete phonetic input. Keeping in mind that all phonetic inputs had a vowel deleted, the responses judged as correct before the sound stimulus was completed are also of relevance to this experiment. Thus, negative RT values are also relevant in this study.

This section displays the results of the one-way ANOVA tests run using SPSS 15.0 for Windows. The statistical analyses on judgments and RTs are reported based on each of the five independent variables (cf. section 4.2). The relationship of the following results to the hypotheses proposed in section 4.2.1 will be discussed in section 4.4 within a report of the overall results of the lexical decision experiment, especially for HYPOTHESIS VI (cf. section 4.2.1.1 (31)), for which the analyses on judgments of correct responses and reaction time independently cannot confirm or dismiss it. HYPOTHESIS VI, thus, will be discussed in section 4.4, taking into account all the results from the lexical decision experiment.

4.3.1. Judgments of correct responses

4.3.1.1. Vowel position and quality

Based on vowel position and quality, phonetic inputs were classified into 6 different combinations of non-high vowels /a, e, o/ and two major analyses were run for V1 or V2 positions. Table 51 displays the results of the one-way ANOVA run on the responses judged as correct (recall they were non-words) based on the quality of the deleted vowel in V1 position. For instance, for the token *casa enorme* (['ka.sa#e.'nor.me], cf. table 2), the phonetic input provided as a sound stimulus with V1 deletion was [ˌka.sa.'nor.me], where V1= /a/. Equally, sound stimuli where V1= /e/ and /o/ where provided, with phonetic inputs such as [ˌkla.so.'bre.ɾa] (from *clase obrera*) and [ˌθer.δa.'sa.δo] (from *cerdo asado*). By listening to these phonetic inputs, subjects had to answer whether what they heard was correct Spanish or not. All subjects except speaker A show the lowest percentage of responses judged as correct when the deleted vowel in V1 position is an /e/. Additionally, more than half of the subjects (A, B, D, E, F and G) judged as correct phonetic inputs were /o/ was deleted more often than phonetic inputs with deletion of vowel /a/.

Table 51
Percentage of responses judged as correct under effect of V1 quality in deletion

Subject	V1=/a/	N	V1=/e/	N	V1=/o/	N	*p*-value	F-value
A	75%	28	81%	32	88%	26	.456	$F(2,83)= .794$
B	61%	28	41%	32	62%	26	.188	$F(2,83)= 1.705$
C	50%	28	25%	32	46%	26	.103	$F(2,83)= 2.338$
D	64%	28	50%	32	65%	26	.409	$F(2,83)= .904$
E	46%	28	31%	32	62%	26	.070	$F(2,83)= 2.742$
F	68%	28	53%	32	69%	26	.368	$F(2,83)= 1.013$
G	64%	28	53%	32	77%	26	.176	$F(2,83)= 1.774$
H	64%	28	22%	32	50%	26	.003*	$F(2,83)= 6.343$
Total	*62%*	*244*	*45%*	*256*	*65%*	*208*	*<.001**	$F(2,685)= 11.967$

Thus, a hierarchy of preference is observed for vowels in V1 position, from better candidate for deletion to worst candidate for deletion: o > a > e. These results suggest that subjects would judge as correct *cerd[o] asado* (the deleted vowel appear in brackets) or *esfuerz[o] enorme*, more often than *ningun[a] oferta* or *cas[a] enorme*; These, in turn, will be judged correct more often than *doc[e] amigos* or *clas[e] obrera*. However, the vocalic preference for deletion in V1 position obtained in the analysis
se patterns in the analyses per speaker did not show to be significant.

A pairwise comparison with a Scheffe post-hoc test for multiple comparisons revealed that when V1 is a front vowel (/e/) then the percentage of responses judged as correct is significantly lower than /a/ or /o/. But no other results shed a light for the vowels /a/ and /o/. Thus, a second set of analyses was run grouping vowels according to features of height, frontness and backness, in order to search for more precise data in terms of vowel quality. In other words, a second set of analysis was done comparing the results based on the vowel which was the target for deletion: for height, low vowel /a/ versus mid vowels /e/ and /o/; for frontness, front vowel /e/ versus non-front vowels /a/ and /o/; finally, for backness, back vowel /o/ versus non-back vowels /e/ and /a/.

First, table 52 illustrates the results of the statistical analysis for vowel height in V1 position. Phonetic inputs with a low height were judged correct more often than phonetic inputs with a mid V1, for six of the eight subjects; equally in one case, and the reverse in another case. The total percentage results in significance with a *p*-value close to .005.

Table 52
Percentage of responses judged as correct under effect of V1 height in deletion

Subject	V1=low	N	V1=mid	N	*p*-value	F-value
A	75%	28	84%	58	.295	F(1,84)= 1.110
B	61%	28	50%	58	.356	F(1,84)= .860
C	50%	28	34%	58	.172	F(1,84)= 1.900
D	64%	28	57%	58	.519	F(1,84)= .419
E	46%	28	45%	58	.890	F(1,84)= .019
F	68%	28	60%	58	.505	F(1,84)= .448
G	64%	28	64%	58	.965	F(1,84)= .002
H	64%	28	34%	58	.009*	F(1,84)= 7.213
Total	*62%*	*224*	*54%*	*464*	*.049**	*F(1,686)= 3.884*

Second, the results in table 53 display the results of the analysis on V1 frontness. They reveal that deletion of front vowels in V1 position are less frequently accepted than deletion of non-front vowels for seven subjects and equally in one case.

Table 53
Percentage of responses judged as correct under effect of V1 frontness in deletion

Subject	V1=front	N	V1=non-front	N	*p*-value	F-value
A	81%	32	81%	54	.979	F(1,84)= .001
B	41%	32	61%	54	.067	F(1,84)= 3.447
C	25%	32	48%	54	.034*	F(1,84)= 4.642
D	50%	32	65%	54	.181	F(1,84)= 1.823
E	31%	32	54%	54	.044*	F(1,84)= 4.192
F	53%	32	69%	54	.157	F(1,84)= 2.039
G	53%	32	70%	54	.110	F(1,84)= 2.611
H	22%	32	57%	54	.001*	F(1,84)= 11.412
Total	*45%*	*256*	*63%*	*432*	*<.001**	*F(1,686)= 23.461*

This result is consistent with the results reported for vowel /e/ in table 51, suggesting that in phonetic inputs such as [ˌkla.so.ˈbre.ɾa] (from *clas[e] obrera*), deletion of the final /e/ in the first word is dispreferred. The lower percentage of correct responses for front vowels over non-front vowels is highly significant in the analysis pulling all subjects together. The exception is speaker A, which shows no difference between front and non-front vowels. The results showed to be significant for subjects C, E and H.

Finally, table 54 displays the results for backness of V1. The overall results show a significant difference that reveals that a greater number of responses are judged correct more often when deletion targets a back vowel in V1 position. All subjects follow this trend, however, the result was only significant for speaker E (p= .0.48).

Table 54
Percentage of responses judged as correct under effect of V1backness in deletion

Subject	V1=back	N	V1=non-back	N	*p*-value	F-value
A	88%	26	78%	60	.273	F(1,84)= 1.218
B	62%	26	50%	60	.330	F(1,84)= .959
C	46%	26	37%	60	.415	F(1,84)= .672
D	65%	26	57%	60	.456	F(1,84)= .562
E	62%	26	38%	60	.048*	F(1,84)= 4.034
F	69%	26	60%	60	.422	F(1,84)= .651
G	77%	26	58%	60	.101	F(1,84)= 2.743
H	50%	26	42%	60	.481	F(1,84)= .502
Total	65%	*208*	53%	*480*	.003*	F(1,686)= 9.167

The results reported so far suggest that vowel quality is a relevant factor influencing deletion. The trend shows that the mid front vowel /e/ in V1 position reduces the percentage of responses judged correct, whereas low /a/ and back /o/ increment it. Therefore, deletion of vowel /e/ is dispreferred in V1 position.

Turning now to V2 position, the results of the first set of analyses on the nature of V2 are displayed in table 55. The largest percentage of correct responses occurs when V2 is the vowel /e/ for all subjects except speaker A, which had a larger number of responses judged correct when deletion targeted the vowel /a/ in V2 position. The overall analysis pulling all subjects together shows this difference is significant. The lowest percentage of responses judged correct was for deletion of vowel /o/ for all subjects except H, who shows a preference for vowel /a/. These results suggest a hierarchy of preference that shows an opposite pattern to V1: /e/ > /a/ > /o/, where deletion of /e/ in V2 position gives a greater number of responses judged correct and deletion of /o/ the smallest number of responses judged correct.

Table 55
Percentage of responses judged as correct under effect of V2 quality in deletion

Subject	V2=/a/	N	V2=/e/	N	V2=/o/	N	*p*-value	F-value
A	91%	32	86%	22	69%	32	.063	F(2,83)= 2.856
B	53%	32	64%	22	47%	32	.488	F(2,83)= .724
C	41%	32	45%	22	34%	32	.714	F(2,83)= .338
D	66%	32	68%	22	47%	32	.197	F(2,83)= 1.654
E	47%	32	64%	22	31%	32	.062	F(2,83)= 2.871
F	72%	32	73%	22	47%	32	.063	F(2,83)= 2.852
G	66%	32	73%	22	56%	32	.459	F(2,83)=.785
H	31%	32	59%	22	47%	32	.122	F(2,83)= 2.156
Total	*58%*	*256*	*66%*	*176*	*47%*	*256*	*<.001**	*F(2, 685)= 8.298*

A pairwise comparison with a Scheffe post-hoc test for multiple comparisons revealed that when the deleted V2 is a back vowel /o/ the percentage of responses judged as correct is significantly lower than when it is a central vowel /a/ or a front vowel /e/ (p<0.001). That is to say, phonetic inputs such as [ˌka.sa.ˈnor.me] (from *casa [e]norme*) with deletion of V2= /e/ and [ˌθer.δa.ˈsa.δo] (from *cerdo [a]sado*) with deletion of V2= /a/ are more often recognized as correct Spanish than inputs with deletion of V2= /o/ such as [ˌkla.so.ˈbre.ɾa] (from *clase [o]brera*). No significant differences were found between /a/ and /e/.

A second set of analyses was run based on the vowel features of height, frontness and backness, and table 56 displays the results of the statistical analysis based on vowel height for V2.

Table 56
Percentage of responses judged as correct under effect of V2 height in deletion

Subject	V2=low	N	V2=mid	N	*p*-value	F-value
A	91%	32	76%	54	.092	F(1,84)= 2.897
B	53%	32	54%	54	.959	F(1,84)= .003
C	41%	32	39%	54	.875	F(1,84)= .025
D	66%	32	56%	54	.364	F(1,84)= .833
E	47%	32	44%	54	.829	F(1,84)= .047
F	72%	32	57%	54	.184	F(1,84)= 1.796
G	66%	32	63%	54	.807	F(1,84)= .060
H	31%	32	52%	54	.064	F(1,84)= 3.519
Total	*58%*	*256*	*55%*	*432*	*.427*	*F(1,686)= .631*

The results show that all subjects except B and H judged correct deletion of a low vowel in V2 more often than a mid vowel. However, the difference revealed not to be significant. The results are not significant either individually or with speakers pooled.

Table 57 illustrates the results of the percentage of responses judged correct for vowel frontness. As expected from the results in table 55, these results show a robust trend for a preference for deletion of a front vowel over a non-front vowel.

Table 57
Percentage of responses judged as correct under effect of V2 frontness in deletion

Subject	V2=front	N	V2=non-front	N	*p*-value	F-value
A	86%	22	80%	64	.493	F(1,84)= .473
B	64%	22	50%	64	.274	F(1,84)= 1.213
C	45%	22	38%	64	.516	F(1,84)= .425
D	68%	22	56%	64	.332	F(1,84)= .954
E	64%	22	39%	64	.046*	F(1,84)= 4.086
F	73%	22	59%	64	.269	F(1,84)= 1.238
G	73%	22	61%	64	.326	F(1,84)= .975
H	59%	22	39%	64	.105	F(1,84)= 2.684
Total	*66%*	*176*	*53%*	*512*	*.001**	*F(1, 686)= 10.171*

All subjects in table 57 judged correct phonetic inputs with a front vowel in V2 position more often than phonetic inputs with a non-front vowel in that position. The overall results revealed to be highly significant.

Finally, table 58 displays the set of results for backness of V2 deletion. All subjects except H judged as correct phonetic inputs with a back vowel in V2 position less often than phonetic inputs with a non-back vowel in that position and the overall results confirmed this trend. This difference was significant overall, as well as for subjects A, E and F.

Table 58
Percentage of responses judged as correct under effect of V2 backness in deletion

Subject	V2=back	N	V2=non-back	N	*p*-value	F-value
A	69%	32	89%	54	.020*	F(1,84)= 5.607
B	47%	32	57%	54	.350	F(1,84)= .884
C	34%	32	43%	54	.457	F(1,84)= .558
D	47%	32	67%	54	.072	F(1,84)= 3.311
E	31%	32	54%	54	.044*	F(1,84)= 4.192
F	47%	32	72%	54	.019*	F(1,84)= 5.767
G	56%	32	69%	54	.257	F(1,84)= 1.301
H	47%	32	43%	54	.703	F(1,84)= .146
Total	*47%*	*256*	*62%*	*432*	*<.001**	*F(1,686)= 13.598*

The results based on vowel quality effects of deletion in V2 position show that overall significant differences are observed in terms of vowel quality for vowel deletion targeting V2: a greater percentage of correct responses is observed when deletion targets vowel /e/ and the lowest percentage of acceptance when deletion targets a back vowel. These results lead to a significant hierarchy of preference for vowel quality regarding deletion in V2: /e/ > /a/ > /o/. This hierarchy runs opposite to that provided for deletion in V1 position, which also shows a significant hierarchy for vowel quality on deletion of vowel sequences: o > a > e. These results run against HYPOTHESIS VI, on vowel position and quality, which stated that vowel deletion of V1 would be judged more often correct than deletion of V2, regardless of vowel quality. Based on the results, vowel quality does affect intuitions about vowel deletion. The analyses run for V2 position suggest that less sonorous and less marked vowels will show higher percentages of responses judged correct: indeed, vowel /e/ is the least sonorous and less marked of the three vowels in the study and it is the vowel that shows a greater number of judgements as correct in that position. On the contrary, in the case of V1 deletion, fewer responses are judged as correct in vowel deletion when V1 is the vowel /e/.

4.3.1.2. Word boundaries

Taking into account the word boundaries as a possible effect on vowel deletion intuitions, an analysis was run comparing phonetic inputs of tokens within word boundaries versus tokens across word boundaries. That is to say, given the tokens *paellera* ([p**ae**jeɾa], with the vowel sequence within word boundaries) and *casa enorme* ([kas**ae**norme], with the vowel sequence across word boundaries) (cf. table 2), the corresponding phonetic inputs were contrasted in the analysis: [pa̲jeɾa], [pe̲jeɾa], [kasa̲norme] and [kase̲norme] (cf. appendix B). HYPOTHESIS VII under (32) predicted that vowel deletion across word boundaries would be judged as correct more often than within word boundaries, i.e. examples [kasa̲norme] and [kase̲norme] would be more often judged correct Spanish than examples [pa̲jeɾa] and [pe̲jeɾa].

The results of the effect of word boundaries on the judgment of correct responses are displayed in table 59 below. All subjects judged correct deletion across word boundaries more often than within word boundaries. This trend was confirmed in the analysis run pulling all subjects together. In all cases, these results revealed to be highly significant, confirming, thus, HYPOTHESIS VII.

Table 59
Percentage of responses judged as correct under effect of word boundaries in deletion

Subject	Within	N	Across	N	*p*-value	F-value
A	50%	12	86%	74	.002*	F(1,84)= 9.912
B	17%	12	59%	74	.005*	F(1,84)= 8.143
C	8%	12	45%	74	.017*	F(1,84)= 5.940
D	8%	12	69%	74	<.001*	F(1,84)= 25.990
E	0%	12	53%	74	.001*	F(1,84)= 13.060
F	17%	12	70%	74	<.001*	F(1,84)= 14.552
G	17%	12	72%	74	<.001*	F(1,84)= 15.678
H	0%	12	51%	74	.001*	F(1,84)= 12.372
Total	*14%*	*96*	*63%*	*592*	*<.001**	*F(1,686)= 93.715*

4.3.1.3. Word type

The statistical analysis based on word type focuses on deletion in vowel sequences across word boundaries, when the type of words involved had a different nature (content or function words). Thus, three word combinations were taken into account: content+content, function+content and content+function. Refer to section 2.1.2.3 for a detailed explanation of these contexts. The purpose of the analysis in this section was to compare judgements of subjects towards deletion of vowel sequences under the effect of word type. Thus, the tokens that were considered were of the following type: content+content as in *clase obrera*, function+content as in *le ofrece* and content+function as in *aire o* (cf. table 2 for the complete set of tokens based on word type). Once again, the tokens were used to create phonetic input with vowel sequence deletion. Therefore, in the case of the examples mentioned above the phonetic inputs for the analysis were [klase̲breɾa], [klaso̲breɾa], [le̲freθe], [lo̲freθe], [ajɾe̲mar] and [ajɾo̲mar] respectively. Regardless of the position of the vowel, in this analysis the HYPOTHESIS VIII predicted that a hierarchy of preference would be seen: deletion in content+function ([ajɾe̲maɾ] or [ajɾo̲maɾ]) should be judged as correct more often than in function+content ([le̲freθe] or [lo̲freθe]); this, in turn, more often than content+content ([klase̲breɾa] or [klaso̲breɾa]). Table 60 displays the percentage for the total responses judged as correct for vowel sequence deletion across word boundaries, based on these word type combinations.

Table 60
Percentage of responses judged as correct under effect of word type in deletion

Subject	Cont.+cont.	N	Func.+cont.	N	Cont.+func.	N	*p*-value	F-value
A	91%	54	67%	12	88%	8	.089	F(2,71)= 2.504
B	69%	54	25%	12	50%	8	.017*	F(2,71)= 4.331
C	48%	54	8%	12	75%	8	.007*	F(2,71)= 5.327
D	72%	54	42%	12	88%	8	.057	F(2,71)= 2.977
E	54%	54	33%	12	75%	8	.186	F(2,71)= 1.722
F	78%	54	33%	12	75%	8	.008*	F(2,71)= 5.153
G	70%	54	67%	12	88%	8	.565	F(2,71)=.575
H	57%	54	25%	12	50%	8	.130	F(2,71)= 2.101
Total	*67%*	*432*	*38%*	*96*	*73%*	*64*	*<.001**	*F(2,589)= 17.583*

The results reveal a general trend for function+content word pairs to have the lowest percentage of responses judged correct, as opposed to the other two word type combinations. This is so for all subjects, even though only three (subjects B, C and F) out of eight show a significant difference. The results are split regarding deletion in content+content and content+ function combinations: subjects A, B, F and H show a higher percentage of correct responses for content+content word combinations, while subjects C, D, E and G for content+function. But the results of the statistical analysis displayed in total reveal a highly significant difference among the three variable groups. Thus, a pairwise comparison with a Scheffe post-hoc test for multiple comparisons was run. The test revealed that deletion in vowel sequences in function+content word combinations are judged as correct less often than deletion in vowel sequences in the other two word combinations ($p<0.001$); but a significant difference was not found between content+content and content+function; indeed due to the opposite behaviours of individual subjects. In sum, the results based on word type show that deletion targeting function+content word combinations is judged correct less often than the other two word-type groups. This result runs against the predictions done in HYPOTHESIS VIII regarding judgment of correct responses. It was predicted that deletion in conten+function word combinations would show a greater number of correct responses than function+content (HYPOTHESIS VIIIa) and this, in turn, more than content+content (HYPOTHESIS VIIIb). The hypothesis fails in that function+content context shows the lowest percentage of judgements as correct. Added to that, no difference is found between the other two contexts, content+content and content+function.

4.3.1.4. Syllable type

The analysis of the effects of syllable type for deletion compared phonetic inputs where the vowel sequence was followed by a coda versus vowel sequences with no coda. In this analysis, recall from section 4.2.1 that only vowel sequences across content+content words were considered. From tokens such as *casa enorme* (no coda) and *cabeza erguida* (coda), for example, phonetic inputs such as [kasanorme] and [kasenorme] ere compared to [kaβeθarγiδa] and [kaβeθerγiδa]. For the complete set of tokens refer to table 2; for the phonetic inputs created from those tokens refer to appendix B. HYPOTHESIS IX predicted that sound stimuli having deletion in codaless syllables would show more instances of judgments as correct than those with syllables containing a coda. Table 61 displays the percentage of responses judged correct for each subject based on the syllable type following the vowel sequence within each phonetic input.

Table 61
Percentage of responses judged as correct under effect of syllable type in deletion

Subject	Coda	N	No coda	N	*p*-value	F-value
A	88%	42	75%	44	.122	F(1,84)= 2.446
B	71%	42	36%	44	.001*	F(1,84)= 11.835
C	45%	42	34%	44	.296	F(1,84)= 1.105
D	71%	42	48%	44	.025*	F(1,84)= 5.187
E	48%	42	43%	44	.684	F(1,84)=.167
F	74%	42	52%	44	.039*	F(1,84)= 4.384
G	64%	42	64%	44	.951	F(1,84)=.004
H	57%	42	32%	44	.018*	F(1,84)= 5.837
Total	*65%*	*336*	*48%*	*352*	*<.001**	*F(1,686)= 20.411*

All subjects except subject G show a greater percentage of responses judged correct for deletion in phonetic inputs containing a coda; four of these are significant across subjects, also significant when the analysis pulled all subjects together. This results run contrary to the statement in HYPOTHESIS IX, which expected deletion in codaless vowel sequences to show greater number of responses judged correct. Instead, the results show that phonetic inputs with a coda are judged as correct more often than phonetic inputs without a coda, this difference being highly significant.

4.3.1.5. Coda type

To further explore the effect of the various coda types in the judgments of correct responses, a final set of analyses is proposed. Recall that four distinct codas were investigated in vowel sequences across content+content word combinations: nasal, liquid, /s/ and obstruent (refer to section 2.1.2.5). Thus, for example, the following tokens containing each a different coda were used to create the phonetic inputs that were object of study in the present experiment: from *otra orquídea*, [otr<u>ar</u>kiδea] and [otr<u>or</u>kiδea]; from *otra oncena*, [otr<u>an</u>θena] and [otr<u>on</u>θena]; from *estaba oscuro*, [estaβ<u>as</u>kuɾo] and [estaβ<u>os</u>kuɾo]; and from *carrera octava,* [kareɾ<u>ak</u>taβa] and [kareɾ<u>ok</u>taβa]. For a complete set of the tokens refer to table 2, for the set of phonetic inputs refer to appendix B. The results of a first analysis are displayed in table 62 below.

Table 62
Percentage of responses judged as correct under effect of coda type in deletion

Subject	Nasal	N	Liquid	N	/s/	N	Obstruent	N	*p*-value	F-value
A	75%	12	100%	10	100%	12	75%	8	.103	F(3,38)= 2.212
B	75%	12	70%	10	92%	12	38%	8	.071	F(3,38)= 2.536
C	33%	12	40%	10	58%	12	50%	8	.661	F(3,38)=.535
D	67%	12	80%	10	75%	12	63%	8	.846	F(3,38)=.271
E	25%	12	70%	10	67%	12	25%	8	.047*	F(3,38)= 2.914
F	75%	12	70%	10	92%	12	50%	8	.234	F(3,38)= 1.486
G	58%	12	70%	10	75%	12	50%	8	.675	F(3,38)=.514
H	67%	12	70%	10	50%	12	38%	8	.477	F(3,38)=.846
Total	*59%*	*96*	*71%*	*80*	*76%*	*96*	*48%*	*64*	*.001**	*F(3,332)= 5.368*

The results in table 62 suggest different trends among subjects. Subjects B, D, F, G and H show the lowest percentage of correct responses for deletion of vowel sequences followed by an obstruent coda, while two more subjects (A and E, the latter with a marginal significance of p= 0,47) show an equally low percentage for obstruent and nasal coda. On the contrary, higher percentages of responses judged correct are observed for /s/ and liquid codas in general. However, these overall results did not reveal to be significant. Therefore, a second test was run pulling all subjects together, in order to check any possible consistency with the previous analysis showing various trends. There, deletion of vowel sequences followed by an obstruent coda shows the lowest percentage of responses judged correct; the highest percentage is for deletion of vowel sequences followed by a /s/ coda. This difference reveals highly significant.

A pairwise comparison with a Scheffe post-hoc test for multiple comparisons revealed two major results: the percentage of judgements as correct of vowel sequences with an obstruent coda is significantly lower than that of liquid coda (p=0.04) and /s/ coda (p=0.004). This result confirms the special status of the apico-alveolar fricative within the obstruent group. However, no other significant differences were found among the various coda groups.

A second set of statistical analyses was run in order to further explore the effects of the codas based on their status as obstruents or sonorants. A first analysis grouped nasals and liquids as sonorants and were compared to all phonetic inputs with an obstruent coda, including /s/. Table 63 below displays the percentages of responses judged correct based on the effect of sonorant or obstruent codas. Only 3 subjects (B, D and H) show a greater percentage of responses judged correct for sonorant coda; the other 5 subjects follow the opposite trend. However, none of the results revealed to be significant.

Table 63
Sonorants versus obstruents: percentage of responses judged as correct under effect of coda type in deletion

Subject	Sonorant	N	Obstruent	N	*p*-value	F-value
A	86%	22	90%	20	.724	F(1,40)= .126
B	73%	22	70%	20	.850	F(1,40)= .036
C	36%	22	55%	20	.236	F(1,40)= 1.449
D	73%	22	70%	20	.850	F(1,40)= .036
E	45%	22	50%	20	.775	F(1,40)= .083
F	73%	22	75%	20	.871	F(1,40)= .027
G	64%	22	65%	20	.929	F(1,40)= .008
H	68%	22	45%	20	.136	F(1,40)= 2.316
Total	*65%*	*176*	*65%*	*160*	*.965*	*F(1,334)= .002*

In order to exclude possible effects of the /s/ coda in the previous results, another statistical test was run, comparing once again the results obtained for deletion of vowel sequences followed by a sonorant coda versus an obstruent coda. But this time, instances of /s/ coda were excluded from the analysis. The results are reported in table 64.

Table 64
Sonorants versus non-sibilant obstruents: percentage of responses judged as correct under effect of coda type in deletion

Subject	Sonorant	N	Obstruent	N	*p*-value	F-value
A	86%	22	75%	8	.477	F(1,28)= .519
B	73%	22	38%	8	.081	F(1,28)= 3.268
C	36%	22	50%	8	.517	F(1,28)= .431
D	73%	22	63%	8	.604	F(1,28)= .275
E	45%	22	25%	8	.329	F(1,28)= .988
F	73%	22	50%	8	.258	F(1,28)= 1.333
G	64%	22	50%	8	.517	F(1,28)= .431
H	68%	22	38%	8	.138	F(1,28)= 2.326
Total	65%	176	48%	64	.022*	F(1,238)= 5.309

All subjects except subject C in table 64 show greater number of judgments as correct for deletion of vowel sequences followed by a sonorant coda. The results reveal a lower percentage of judgment as correct for obstruent codas (48%) than sonorants (65%), this difference being significant (*p*=.022). Thus, two relevant observations are obtained from the analyses on coda type. On the one hand, deletion under the effect of obstruent codas results in a lower percentage of responses judged correct than sonorant codas (nasal or liquid), this result being significant; on the other hand, the high percentage of responses judged correct under the effect of the /s/ coda confirms it special status within the obstruent group in Spanish, as it was predicted in HYPOTHESIS Xc.

4.3.1.6. Summary

The following lines sum up the results on the percentage of judgments of responses as correct based on the various independent factors.

a) In terms of vowel position and quality, a hierarchy of preference for specific vowel target for deletion is discovered. On the one hand, in V1 position, deletion of vowel

/o/ is judged correct more often than deletion of vowel /a/, and this in turn more than deletion of vowel /e/. No significant results are obtained for the distinctions between vowels /a/ and /o/, but the asymmetry in deletion results for vowel /e/ versus vowels /a/ and /o/ is significant. On the contrary, for V2 position, a preference for deletion of vowel /e/, less for deletion of vowel /a/ and even less for deletion of vowel /o/ is observed. These results show to be significant for deletion of vowel /o/ in V2 position versus vowels /a/ and /e/, although there is not a significant distinction between vowels /a/ and /e/.

b) Deletion across word boundaries is significantly better judged than deletion within word boundaries.

c) Across word boundaries, deletion in function+content words is dispreferred over content+content and content+function. But no relevant differences are obtained between content+content and content+function.

d) Regarding vowel sequences followed by a coda, deletion revealed to be better in coda contexts than in codaless phonetic inputs, this difference being highly significant.

e) Finally, among the various codas suggested, results show a significant dispreference for deletion in phonetic inputs with obstruent codas, excluding /s/ coda, judging deletion better when the coda is a sonorant. The general results actually suggest a clear distinction between obstruent codas in general and the sibilant /s/ obstruent. Deletion of vowel sequences followed by a /s/ coda shows a high percentage of responses judged correct, unlike the group of other obstruent codas. Indeed, this significant result underlines the special status of /s/ in Spanish.

For the sake of clarity, the following figure presents the major results obtained throughout this section:

Figure 19
Summary of the results on judgment intuitions about the effects of 5 phonological factors on deletion of vowel sequences

	Deletion of vowel sequences judged as correct MORE often		*Deletion of vowel sequences judged as correct LESS often*
1. Vowel position and quality	V1= /a/ and /o/ V2= /e/		V1= /e/ V2= /a/ and /o/
2. Word boundaries	across		within
3. Word type	content+ content content+function		function +content
4. Syllable type	coda		no coda
5. Coda type	/s/	nasal liquid	obstruents (excluding /s/)

4.3.2. Reaction times of responses judged as correct

This section follows up directly from section 4.3.1 above. In that section the percentage of the judgments of the subjects was studied on vowel sequence deletion under the effect of 5 phonological contexts. In this section, the reaction time to make those judgements is analyzed. The starting point for this section is the assumption that shorter RTs reflect less hesitation by the subjects in answering to the lexical experiment. If subjects hesitate less in their answers to whether what they heard was correct Spanish or not in a given context (refer to section 4.2 for the description of the experimental design), then vowel deletion in that context could be expected to be better accepted. The next lines report the results of the analyses on RT. These results follow the order displayed for the five phonological factors as in the previous sections of this thesis.

4.3.2.1. Vowel position and quality

Recall from section 4.3.1.1 that both vowel position and quality revealed to have an effect on deletion of vowel sequences: (i) under the effect of V1, deletion of /a/ and /o/ was judged as correct more often than deletion of /e/; (ii) under the effect of V2, deletion of /e/ was judged as correct more often than deletion of /a/ and /o/. If the contexts that favour deletion are those that subjects responded to as judging them as correct, then we should expect to find longer reaction times for /e/ than for /a/ and /o/ in V1 position and shorter RTs for /e/ than for /a/ and /o/ in V2 position.

A first set of analyses was done focusing on vowel quality in V1 position, but no relevant results were obtained. Table 65 below reports the results of mean reaction times of the responses judging deletion of a vowel sequence correct under the effect of V1 quality. These results do not reveal any significant results, or any possible trends among subjects. The post hoc tests also fail to show a significant difference to support any distinction.

Table 65
Mean RTs of responses judged as correct under effect of V1 quality in deletion

Subject	V1=/a/	N	V1=/e/	N	V1=/o/	N	*p*-value	F-value
A	402.41	18	406.00	24	433.98	23	.962	F(2,62)= .039
B	370.97	16	537.82	11	523.04	16	.533	F(2,40)= .638
C	733.53	9	835.09	7	680.99	10	.820	F(2,23)= .200
D	195.38	18	196.48	16	198.63	17	.999	F(2,48)= .001
E	285.22	13	401.84	10	267.64	16	.485	F(2,36)= .738
F	315.36	19	306.39	17	309.04	18	.993	F(2,51)= .007
G	238.54	17	190.45	17	155.49	20	.573	F(2,51)= .563
H	1021.34	15	1013.18	6	952.45	10	.945	F(2,28)= .057
Total	*418.98*	*125*	*399.94*	*108*	*392.43*	*130*	*.871*	*F(2,360)= .138*

Thus, following the procedures in section 4.3.1, a second set of analyses was run taking into account differences of vowel height, frontness and backness. Table 66 displays the results based on vowel height. But the analysis of RT values did not reveal any trends. Five subjects (A, B, C, D and E) revealed longer RTs for phonetic inputs with a mid vowel in V1 position, while three subjects (F, G and H) showed the opposite trend. This difference, however, was not significant.

Table 66
Mean RTs of responses judged as correct under effect of V1 height in deletion

Subject	V1=low	N	V1=mid	N	*p*-value	F-value
A	402.41	18	419.69	47	.878	F(1,63)= .024
B	370.97	16	529.06	27	.261	F(1,41)= 1.301
C	733.53	9	744.44	17	.957	F(1,24)= .003
D	195.38	18	197.58	33	.967	F(1,49)= .002
E	285.22	13	319.26	26	.729	F(1,37)= .121
F	315.36	19	307.75	35	.907	F(1,52)= .014
G	238.54	17	171.55	37	.336	F(1,52)= .942
H	1021.34	15	975.22	16	.802	F(1,29)= .064
Total	*418.98*	*125*	*395.84*	*238*	*.612*	*(F1,361)= .257*

The results on the analysis run on RTs for vowel frontness, in table 67 below, show shorter RTs for deletion of front V1 vowels in subjects A, D, F and G; the other four (B, C, E and H) show shorter RTs for non-front V1 vowels. The possible differences between the results in the two groups were not significant. Nor was the results obtained from the analysis on subjects pulled together. Thus, no conclusive results can be obtained concerning frontness.

Table 67
Mean RTs of responses judged as correct under effect of V1 frontness in deletion

Subject	V1=front	N	V1=non-front	N	*p*-value	F-value
A	406.00	24	420.12	41	.893	F(1,63)= .018
B	537.82	11	447.00	32	.562	F(1,41)= .342
C	835.09	7	705.87	19	.554	F(1,24)= .361
D	196.48	16	196.96	35	.993	F(1,49)= .000
E	401.84	10	275.52	29	.230	F(1,37)= 1.488
F	306.39	17	312.28	37	.930	F(1,52)= .008
G	190.45	17	193.65	37	.964	F(1,52)= .002
H	1013.18	6	993.78	25	.934	F(1,29)= .007
Total	*399.94*	*108*	*405.44*	*255*	*.908*	*F(1,361)= .013*

Table 68 displays the results for vowel backness. Five out of the eight subjects (C, E, F, G and H) show shorter RTs for the back vowels, when the other three (A, B and D) show longer RTs for back vowels in V1 position. The analysis pulling all subjects together also shows shorter RTs for back vowels in V1 position. None of these results, however, reveal to be significant.

Table 68
Mean RTs of responses judged as correct under effect of V1 backness in deletion

Subject	V1=back	N	V1=non-back	N	*p*-value	F-value
A	433.98	23	404.46	42	.780	F(1,63)= .079
B	523.04	16	438.95	27	.552	F(1,41)= .360
C	680.99	10	777.96	16	.626	F(1,24)= .243
D	198.63	17	195.89	34	.960	F(1,49)= .003
E	267.64	16	335.93	23	.468	F(1,37)= .538
F	309.04	18	311.12	36	.975	F(1,52)= .001
G	155.49	20	214.50	34	.379	F(1,52)= .788
H	952.45	10	1019.01	21	.735	F(1,39)= .116
Total	*392.43*	*130*	*410.15*	*233*	*.695*	*F(1,361)= .154*

In sum, none of the results so far reveal significant information about vowel position and quality effects on deletion. Only two general trends can be suggested: (i) regarding vowel height, a tendency for shorter RTs is observed for a majority of subjects when V1 is a low vowel; and (ii) shorter RTs are also observed for phonetic inputs with a back vowel in V1 position.

Turning now to the effects of V2, the first analysis run on RTs displayed in table 69 below failed to show a significant differences overall. All subjects except B and E show the longest RT values for vowel /o/ and half of the subjects (B, C, D and F) show the shortest RTs for vowel /e/, which results in a hierarchy of preference for vowels in V2 position: deletion of /e/ shows the shortest RTs, then deletion of /a/ and then deletion of /o/, with the longest RT values. But none of these results revealed to be significant, neither did the post hoc tests.

Table 69
Mean RTs of responses judged as correct under effect of V2 quality in deletion

Subject	V2=/a/	N	V2=/e/	N	V2=/o/	N	*p*-value	F-value
A	353.34	28	363.95	16	535.83	21	.249	F(2,62)= 1.422
B	525.50	16	420.48	14	455.81	13	.809	F(2,40)= .214
C	721.52	12	640.48	6	844.51	8	.737	F(2,23)= .309
D	171.23	21	164.90	15	264.51	15	.232	F(2,48)= 1.506
E	368.73	15	270.59	14	268.94	10	.585	F(2,36)= .545
F	313.97	23	261.65	16	357.02	15	.505	F(2,51)= .692
G	167.40	21	203.61	15	212.95	18	.821	F(2,51)= .198
H	934.34	8	937.83	10	1082.36	13	.738	F(2,28)= .307
Total	*377.07*	*144*	*362.58*	*106*	*476.55*	*113*	*.075*	*F(2,360)= 2.610*

A second set of analyses was run based on the different features of vowel (height, frontness and backness). In the analysis on RTs based on vowel height, displayed on table 70, five of the eight subjects (A, C, D, G and H) show shorter RTs when V2 is a low vowel. Again, these differences did not reveal to be significant.

Table 70
Mean RTs of responses judged as correct under effect of V2 height in deletion

Subject	V2=low	N	V2=mid	N	*p*-value	F-value
A	353.34	28	461.50	37	.287	F(1,63)= 1.154
B	525.50	16	437.49	27	.533	F(1,41)= .395
C	721.52	12	757.07	14	.855	F(1,24)= .034
D	171.23	21	214.70	30	.407	F(1,49)= .701
E	368.73	15	269.90	24	.297	F(1,37)= 1.120
F	313.97	23	307.80	31	.922	F(1,52)= .010
G	167.40	21	208.70	33	.535	F(1,52)= .390
H	934.34	8	1019.52	23	.685	F(1,29)= .167
Total	*377.07*	*144*	*421.39*	*219*	*.318*	*F(1,361)=1.002*

For vowel frontness, results in table 71 reveal a general trend with a preference for the front vowel, since all subjects except G show lower RTs when V2 is a front vowel. However, none of the results showed any significance.

Table 71
Mean RTs of responses judged as correct under effect of V2 frontness in deletion

Subject	V2=front	N	V2=non-front	N	*p*-value	F-value
A	363.95	16	431.55	49	.564	F(1,63)= .337
B	420.48	14	494.26	29	.613	F(1,41)= .260
C	640.48	6	770.72	20	.571	F(1,24)= .331
D	164.90	15	210.10	36	.425	F(1,49)= .648
E	270.59	14	328.82	25	.546	F(1,37)= .371
F	261.65	16	330.96	38	.306	F(1,52)= 1.069
G	203.61	15	188.43	39	.834	F(1,52)= .044
H	937.83	10	1025.97	21	.654	F(1,29)= .205
Total	*362.58*	*106*	*420.81*	*257*	*.222*	*F(1,361)=1.496*

Finally, the RT analysis on backness for V2 position displayed in table 72 shows shorter RTs when V2 is a non-back vowel for 6 out of the 8 subjects (A, C, D, F, G and H). Also in the analysis run pulling all subjects together reflected longer RTs for a back vowel in V2 position. No significant results were obtained overall.

Table 72
Mean RTs of responses judged as correct under effect of V2 backness in deletion

Subject	V2=back	N	V2=non-back	N	*p*-value	F-value
A	535.83	21	357.20	44	.094	F(1,63)= 2.883
B	455.81	13	476.49	30	.890	F(1,41)= .019
C	844.51	8	694.51	18	.473	F(1,24)= .530
D	264.51	15	168.60	36	.086	F(1,49)= 3.062
E	268.94	10	321.35	29	.621	F(1,37)= .248
F	357.02	15	292.50	39	.350	F(1,52)= .888
G	212.95	18	182.49	36	.658	F(1,52)= .198
H	1082.36	13	936.28	18	.432	F(1,29)= .636
Total	*476.55*	*113*	*370.93*	*250*	*.024**	*F(1,361)= 5.157*

In sum, none of the tables on vowel quality effects regarding V2 position show significant results for RTs, but a certain pattern of preference is suggested. Shorter RT values have been reported when V2 is a front than when V2 is a non-front vowel (/e/ > /a/ and /o/); also shorter RTs have been shown for low vowel over mid vowel (/a/ > /e/ and /o/). Thus, the difference between /a/ and /e/ cannot be clarified based on these results, but it is suggested that deletion of the back vowel /o/ in V2 position reflects longer RT values.

Regarding vowel position and quality, no conclusions can be drawn on the basis of RT values. According to HYPOTHESIS VI, we should expect to have shorter reaction times for instances of deletion of vowels in V1 position regardless of their quality. But the overall analyses run for V1 suggest in fact that the longest RTs occur in deletion of vowel /e/. Shorter RTs do occur for vowel /e/ in V2 position, but a more sonorous vowel such as the low vowel /a/ also shows shorter RTs in that position. These results, similarly to those in section 4.3.1.1 contradict HYPOTHESIS VI, in that vowel quality does have an effect on deletion of vowel sequences.

4.3.2.2. Word boundaries

Section 4.3.1.2 exemplified the two contexts that were analyzed to find out if they had an effect on deletion of vowel sequences. It was shown that across word boundaries subjects judged as correct deletion of vowel sequences more often than within word boundaries. If across word boundaries deletion is judged more often correct, then we could expect to have shorter RTs in this contexts. The statistical analysis for the RTs based on word boundaries reveal significant results for a number of subjects, as table 73 below displays.

Table 73
Mean RTs of responses judged as correct under effect of word boundaries in deletion

Subject	Within	N	Across	N	*p*-value	F-value
A	811.70	4	476.32	25	.144	F(1,27)= 2.268
B	414.99	1	385.75	14	.947	F(1,13)= .005
C	703.26	1	729.13	11	.964	F(1,10)= .002
D	--	0	215.08	21	--	--
E	--	0	359.12	19	--	--
F	769.07	2	349.33	21	.024*	F(1,21)= 5.876
G	461.12	2	194.77	26	.142	F(1,26)= 2.290
H	--	0	1178.96	11	--	--
Total	*682.54*	*10*	*419.17*	*148*	*.064**	*F(1,156)= 3.481*

In this table, the RTs of subjects D, E and H for phonetic inputs within word boundaries were not valid, for being over 2000 ms (outliers). Thus, their results for deletion across word boundaries could not be taken into account for the report. The RTs of four out of the total of five subjects (5 subjects with valid data, i.e. A, B, C, F and G), as well as in the analysis run pulling all subjects together, were shorter for phonetic inputs with deletion across word boundaries. This difference is significant and confirms the expectations from HYPOTHESIS VII regarding reaction time.

4.3.2.3. Word type

Section 4.3.1.3 exemplified the contexts based on word type combinations in which deletion of vowel sequences was studied. The results in that section, revealed less judgments of responses as correct in deletion of vowel sequences in function+content word combinations than in the other two word combinations. Table 74 shows the mean RT values of responses judged correct based on the word type combinations.

Table 74
Mean RTs of responses judged as correct under effect of word type in deletion

Subject	Cont.+cont.	N	Func.+cont.	N	Cont.+func.	N	*p*-value	F-value
A	437.50	11	594.21	8	390.30	6	.610	F(2,22)= .505
B	486.30	7	680.27	3	-11.11	4	.046*	F(2,11)= 4.146
C	707.25	4	1614.60	1	596.14	6	.221	F(2,8)= 1.831
D	228.47	9	287.96	5	145.81	7	.536	F(2,18)= .646
E	364.19	9	539.94	4	230.97	6	.394	F(2,16)= .988
F	326.51	11	510.64	4	283.64	6	.316	F(2,18)= 1.229
G	184.35	11	300.68	8	90.09	7	.236	F(2,23)= 1.537
H	1016.48	5	1847.83	2	1047.63	4	.240	F(2,8)= 1.715
Total	*404.20*	*67*	*575.78*	*35*	*321.82*	*46*	*.031**	*F(2,145)= 3.547*

On the one hand, shorter RTs are observed in phonetic inputs of content+function word combinations for all subjects, except for speaker H, who shows shortest RTs for content+content combinations. On the other hand, the longest RTs are shown for function+content combinations in all subjects. These results were not significant, but the analysis run pulling all subjects together did show a significant result following that trend: shortest RTs occur in content+function and longest RTs occur in function+content word combinations. A pairwise comparison with a Scheffe post-hoc test for multiple comparisons was run and the findings revealed that the mean RT value of function+content was significantly greater than the mean RT value for content+content (p=.035) and that of content+function (p=.022), but no significant difference was found between content+content and content+function. All of these results go along the results obtained in section 4.3.1.3 for judgements of correct responses. Thus, the results in the RT analyses obtained in this section actually confirm a dispreference for deletion in vowel sequences of function+content word combinations. This result, in turn, fails to confirm HYPOTHESIS VIII, which stated a hierarchy of contextual preferences for deletion of vowel sequences based on word type as follows: content+function better than function+content better than content+content (cf. section 4.3.1.3).

4.3.2.4. Syllable type

The results from the statistical analysis on RTs based on the effect of occurrence of a coda on deletion of vowel sequences are displayed next, in table 75 below. Section 4.3.1.4 showed that deletion of vowel sequences followed by a coda were judged as correct more often than without a coda. If deletion in coda environments occurs more often than in codaless vowel sequences, then it should be expected that RTs in judgments of deletion in sequences with a coda should be shorter. Indeed, shorter RT values are reported for six out of eight subjects (A, D, E, F, G and H) for deletion in phonetic inputs with a coda, as table 75 next illustrates. The results pulling all the subjects together also follow this trend. None of these differences, however, revealed to be significant and HYPOTHESIS IX could not be confirmed or dismiss.

Table 75
Mean RTs of responses judged as correct under effect of syllable type in deletion

Subject	Coda	N	No coda	N	*p*-value	F-value
A	328.17	36	476.32	25	.143	F(1,59)= 2.202
B	514.46	28	385.75	14	.385	F(1,40)= .772
C	752.40	14	729.13	11	.909	F(1,23)= .013
D	184.01	30	215.08	21	.554	F(1,49)= .355
E	259.27	20	359.12	19	.278	F(1,37)= 1.210
F	254.48	31	349.33	21	.109	F(1,50)= 2.663
G	169.87	26	194.77	26	.701	F(1,50)= .149
H	897.75	20	1178.96	11	.137	F(1,29)= 2.344
Total	*379.12*	*205*	*419.17*	*148*	*.368*	*F(1,351)= .811*

4.3.2.5. Coda type

Another set of analyses was run to further explore the effects of coda types on deletion. These coda types are exemplified in section 4.3.1.5. The statistical analysis run for RTs based on coda type displayed in table 76 did not reveal any significant differences, in the analysis run per subject, nor pulling all subjects together.

Table 76
Mean RTs of responses judged as correct under effect of coda type in deletion

Subject	Nasal	N	Liquid	N	s/	N	Obstruent	N	*p*-value	F-value
A	270.47	9	276.46	9	401.52	12	345.60	6	.841	F(3,32)= .277
B	768.99	9	438.57	6	315.23	10	566.73	3	.189	F(3,24)= 1.723
C	569.56	3	567.46	2	1080.18	5	572.27	4	.317	F(3,10)= 1.338
D	189.53	8	193.84	8	219.90	9	94.90	5	.573	F(3,26)= .678
E	281.86	3	330.88	7	157.32	8	382.50	2	.378	F(3,16)= 1.100
F	279.48	9	242.67	7	235.44	11	271.27	4	.955	F(3,27)= .108
G	240.96	7	172.28	6	108.67	9	179.52	4	.741	F(3,22)= .420
H	930.30	7	867.74	5	955.41	6	685.90	2	.892	F(3,16)= .205
Total	*438.90*	*55*	*343.85*	*50*	*370.13*	*70*	*349.24*	*30*	*.601*	*F(3,201)=.623*

The results in table 76 show that four out of the eight subjects (B, E, F and G) have the shortest RT values for /s/ coda; but the other four subjects (A, C, D and H) show the longest RT values in /s/ coda. Added to that, shortest RT values are also observed for obstruents in the case of subjects D and H, for nasal in subject A and liquid coda for subject C and also for the result pulling all subjects together. On the contrary, the longest RT values are also found for nasal codas in three subjects (B, F and G), as well as in the result pulling all subjects together and one subject (E) shows longest RTs for obstruent coda.

A second round of analyses was run to test the relation between sonorant and obstruent groups. Table 77 displays these results, in which a general trend is observed of shorter RTs in obstruent codas (subjects B, D, E, F, G and H, as well as the total result pulling all subjects together). No significant results were found, however.

Table 77
Sonorants versus obstruents: mean RTs of responses judged as correct under effect of coda type in deletion

Subject	Sonorant	N	Obstruent	N	*p*-value	F-value
A	273.47	18	382.88	18	.381	F(1,34)= .788
B	636.82	15	373.26	13	.135	F(1,26)= 2.379
C	568.72	5	854.44	9	.297	F(1,12)= 1.186
D	191.68	16	175.25	14	.781	F(1,28)= .078
E	316.18	10	202.36	10	.248	F(1,18)= 1.426
F	263.37	16	245.00	15	.783	F(1,29)= .077
G	209.26	13	130.47	13	.386	F(1,24)= .779
H	904.23	12	888.03	8	.935	F(1,18)= .007
Total	*393.64*	*105*	*363.87*	*205*	*.589*	*F(1,203)=.292*

A second analysis was run excluding /s/ from the obstruent group, but the results of this test, in table 78 below, show that four subjects (A, C, E and F) show shorter RTs in sonorant codas, whereas the other four (B, D, G and H) show shorter RTs for obstruent codas. The overall results pulling all subjects together reflect shorter RTs for obstruent codas. None of these results, however, revealed any significant differences either.

Table 78
Sonorants versus non-sibilant obstruents: mean RTs of responses judged as correct under effect of coda type in deletion

Subject	Sonorant	N	Obstruent	N	*p*-value	F-value
A	273.47	18	345.60	6	.657	F(1,22)= .202
B	636.82	15	566.73	3	.815	F(1,16)= .057
C	568.72	5	572.27	4	.988	F(1,7)= .000
D	191.68	16	94.90	5	.247	F(1,19)= 1.425
E	316.18	10	382.50	2	.688	F(1,10)= .170
F	263.37	16	271.27	4	.928	F(1,18)= .009
G	209.26	13	179.52	4	.832	F(1,15)= .046
H	904.23	12	685.90	2	.430	F(1,12)= .668
Total	*393.64*	*105*	*349.24*	*30*	*.554*	*F(1,133)=.352*

In sum, the RT analyses run for coda type do not provide significant results at all and no concluding statements can be provided. Only a trend is suggested overall, regarding obstruent codas: deletion in vowel sequences followed by an obstruent coda seems to report shorter RTs. These results, however, exclude /s/, which seems to behave separate from the obstruent group. If this trend is correct, then HYPOTHESIS Xa regarding reaction time is confirmed, for shorter RTs are expected in obstruent coda contexts. HYPOTHESIS Xc, however, concerning the status of the /s/ coda, could not be confirmed.

4.3.2.6. Summary

The statistical analyses run for RTs do not reveal significant results overall, except for word boundaries and word type. Mostly a number of trends are suggested. These are summarized as follows.

a) In terms of vowel position and quality, backness tends to produce shorter RTs in V1 position, but longer RTs in V2 position. Added to that, shorter RTs are also produced with a low vowel both in V1 and V2 position, and also with a front vowel in V2 position.

b) RT values were significantly shorter across word boundaries than within word boundaries.

c) Across words, deletion in function+content words produced significantly longer RTs than in other word combinations and the significantly shortest RTs were revealed in content+function word combinations.

d) The presence of a coda also revealed shorter RTs, although this result only suggests a trend, no significance was found.

e) Finally, obstruent codas are also suggested to report shorter RTs. Again, this was not a significant result.

The following figure illustrates the significant results on the analysis of RTs on deletion of vowel sequences under the effect of the 5 phonological variables:

Figure 20
Summary of the results on RT values about the effects of 5 phonological factors on deletion of vowel sequences

	Shorter RT values	*Longer RT values*
1. Vowel position and quality	V1= /o/, /a/ V2= /e/, /a/	V1= /e/ V2= /o/
2. Word boundaries	across	within
3. Word type	content+function	function +content
4. Syllable type	coda	no coda
5. Coda type	obstruents	elsewhere

4.4. Summary of the results on lexical decision

This section brings together the results from both dependent variables, judgment of correct responses and reaction time on deletion, summing up the most important findings in the experiment. The results from the analyses on vowel position and quality show, first of all, a lower percentage of responses judged correct when V1 is the front vowel /e/ than when V1 is a non-front vowel, this difference being highly significant (tables 51 through 54). The results from the RT analysis also revealed longer RTs for vowel /e/ in V1 position (tables 65 through 68). Both of these results suggest that deletion of vowel /e/ in V1 position is rather judged incorrect, a conclusion that runs against expectations: HYPOTHESIS VI stated that deletion would show a greater number of responses judged correct and shorter RTs in deletion instances of V1, regardless of the quality of the vowels involved. But the results from the experiment suggest the following trend: less sonorous or less marked vowel /e/ shows fewer responses judged correct and longer RTs in deletion of vowel sequences under the effect of V1 position.

Second, although no significant differences were found for the behavior of vowels /a/ and /o/ in V1 position regarding judgment of correct responses, a greater acceptance of back vowel deletion is suggested (table 68), which would lead to a hierarchy of preference: /o/ better than /a/ better than /e/ in V1 position. But the results from the analyses on RT do not show shorter RTs for one of these vowels than for the other, and therefore no conclusions can be drawn about non-front vowels /a/ and /o/. Equally, no significant differences were found between /e/ and /a/ in V2 position regarding judgments of correct responses (tables 55 through 58); and no further information was obtained from the analyses on RT regarding these two vowels. However, a trend is suggested that is further supported by the analysis run on RTs regarding the back vowel: a smaller acceptance and longer RTs are revealed for deletion of /o/ in V2 position, than deletion of vowels /e/ and /a/ (tables 69 through 72). This trend about V2 runs, once again, against the expectations predicted in HYPOTHESIS VI.

With regard to word boundaries, the results of the statistical analyses robustly confirm HYPOTHESIS VII, which predicted that deletion is better accepted across word boundaries. Indeed deletion is judged correct less often within word boundaries (table 59). The analysis on RTs supports this result, showing significantly longer RT values for the responses judged correct within word boundaries (table 73).

For phonetic inputs based on word type, the results revealed the lowest percentage of responses judged correct in function+content word combinations, although no differences were provided for the other two groups (table 60). The analysis on RTs supported this difference, showing the largest RTs in function+content word combinations (table 74); this result on RTs was not significant, however. But another significant result was obtained regarding RTs, which reveals shorter RT values for content+function combinations than for the other two groups. This result partly confirms HYPOTHESIS VIII, which expected that content+function word combinations would be preferred contexts than function+content once for deletion (HYPOTHESIS VIIIa), showing a greater number of responses judged correct and shorter RTs. No conclusions can be drawn for judgment of correct responses, but RTs are confirmed to be the shortest for content+function word combinations.

Deletion in phonetic inputs with a coda were judged correct significantly more often than in phonetic inputs without a coda (table 61), and this result is further suggested through the analysis on RTs, which revealed a trend for shorter RTs in phonetic inputs with a coda (table 75). Thus, for syllable type effects, HYPOTHESIS IX is robustly dismissed, and the opposite statement is true: deletion is better judged and the reaction times of the correct responses are shorter in vowel sequences with a coda.

The analyses based on the effects of codas in the vowel sequences revealed a significant result for obstruent codas, which are judged correct less often than the rest of coda types (tables 62 through 64). This group excludes the /s/ coda from the group, which was revealed to show the highest percentage of responses judged correct (table 62). Further information form the analysis on RTs did not provide with significant results at all with respect to coda type, but suggested a parallel trend for obstruent codas, which revealed the shortest RTs from all coda types (tables 76-78); no revealing information was obtained for the /s/ coda regarding RTs. Thus, based on these results, HYPOTHESIS Xa on the one hand, which stated that obstruent codas would favour a greater number of responses judged as correct and shorter RTs, is confirmed. On the other hand, no results were conclusive about HYPOTHESIS Xb. Finally, HYPOTHESIS Xc, expecting /s/ codas to show a greater number of responses judged correct and shorter reaction times is also confirmed, suggesting a distinction of the sibilant from the rest of the obstruent codas. The results on the RTs based on coda type, did not support this last conclusion, however.

CHAPTER 5

CONCLUSIONS

Vowel reduction in a strong syllable-timed language such as Spanish is not so easy to be captured by the naked eye (ear) and requires fine-grained experiments which are the basis of the present research. This dissertation has investigated hiatus resolution of non-high vowels in Spanish, under the effect of five phonological contexts: vowel position and quality, word boundaries, word type, syllable type and coda type. The main purpose is to gain knowledge about the gradient nature of hiatus resolution in this language. Vowels in hiatus in Spanish are resolved via different strategies (acoustic diphthongization, gliding, coalescence or deletion) at the phonetic output (refer to section 1.4.2). This dissertation sheds light on how different segmental and prosodic factors (vowel position and quality, word boundaries, word type, syllable type and coda type) have an effect on the choice of one of these strategies or another to resolve hiatus. In order to achieve that, a double experiment has been developed, which includes a production task and a lexical decision task.

The production task tests the effects of the five segmental and prosodic factors (vowel position and quality, word boundaries, word type, syllable type and coda type) on the realization of non-high vowel sequences, originally in hiatus, in Spanish. Eight native speakers of the language were asked to read a list of sentences containing specific vowel sequences and their realizations were recorded for posterior analysis. The variables that are analyzed from the recorded data are duration of the output vowel sequence, F1 and F2 formant frequency values of the output vowel(s), the strategy of hiatus resolution that is used in the realization of each vowel sequence and which vowel in the sequence is targeted for hiatus resolution. Duration and formant frequency are measured first. Based on those measurements, vowel sequences are classified next into the category that defines their realization: hiatus, acoustic diphthongization, gliding, coalescence or deletion. Finally, for those instances in which hiatus resolution has taken place, the vowel that has been targeted is recorded. The experimental design is described in chapter 2; results are analyzed in chapter 3.

The lexical decision task focuses on the strategy of deletion. It tests the intuitions of the same subjects that carry out the production task, about the acceptance of deletion under the effect of the same five phonological factors. The reason for concentrating on this strategy of hiatus resolution specifically is due to the fact it is understood as the most radical strategy of the phenomenon (cf. table 7 and section 4.1), by showing the greatest durational reduction of all strategies and elision of one complete segment within the vowel sequence. Subjects were asked to listen to sound inputs of words containing vowel sequences that had previously undergone deletion. Subjects listened to those phonetic inputs and judged whether what they heard sounded correct in Spanish or not. Their responses judged as correct as well as the reaction time to answer were recorded for posterior analysis. A description of the experimental design and the analysis of the results are provided in chapter 4. The results from the lexical decision task serve to complement the results from the production task and, although they are not categorical, they help shedding some light on the factors that predictably have an effect on hiatus resolution.

5.1. Analysis of the data and interpretation of the experimental results

5.1.1. Vowel position and quality

The analyses based on the effect of vowel position and quality reveal interesting results about the effect of the nature of the vowels in the VV-sequence. The production results overall suggest a trend that is further supported by the results from the lexical decision study. To begin with, vowel /e/ is suggested to produce shorter vowel sequences than the other two vowels (/a/ and /o/) regardless of its position. This trend is confirmed by the analyses on hiatus resolution strategies (refer to section 3.3), which show significantly greater chances to resolve hiatus (except deletion) in sequences that contain this vowel. Based on these results, it can be claimed that shorter duration in the production of the vowel sequence is directly related to more chances to have hiatus resolution. Added to that, vowel /e/ is suggested to be the preferred target when hiatus resolution takes place both in V1 and V2 position. But deletion of vowel /e/ is only significantly more common when V2 is the low vowel /a/, i.e. in /ea/ vowel sequences. Moreover, deletion is the preferred choice of hiatus resolution when V1 is the back vowel /o/, this is a highly significant statistical result.

On the one hand, the result on deletion concerning vowel /e/ is consistent with the results from the lexical decision experiment, which reveal that deletion of vowel /e/ produces lower percentages of responses judged as correct and the reaction times are longer in those responses that were actually judged as correct. On the other hand, vowels /a/ and /o/ reveal longer vowel sequences and more chances to maintain hiatus or to resolve it through acoustic diphthongization at most, suggesting a preference for vowel /a/ in V1 position and vowel /o/ in V2 position. Further observations concerning these two vowels suggest indeed that when the vowel /o/ is in V2 position, there are fewer responses judged as correct and the reaction times are longer for those responses. Instead, when the vowel /a/ is in V2 position, centralization of rising sonority sequences (/ea/ and /oa/) results in more chances to resolve hiatus, via coalescence, than centralization of falling sonority sequences (/ao/). These results show a preference of vocalic sequences for hiatus resolution that can be exemplified through the following hierarchy of preference:

(36) + *hiatus* -------------------------------------- − *hiatus*

/ao/	/oa/	/ea/
		/ae/
		/eo/
		/oe/

In all, the effect of vowel position and quality is confirmed but, although an interaction is reflected in the results between the two, greater effects of vowel quality over those of vowel position are seen throughout. First, sequences containing the vowel /e/ are expected to resolve hiatus more often than other vowel sequences; this vowel is also a better target for resolution, regardless of its position. Second, vowels /a/ and /o/ produce longer sequences and resolve hiatus less often. Moreover, when these vowels appear precisely in the sequence /ao/, the chances to maintain hiatus increase. Added to that, vowel /a/ in V2 position leads to more instances of coalescence, which in turn leads to the realization of a more centralized vowel.

HYPOTHESIS I has originally been stated in this dissertation as follows: V1 suffers durational reduction more often than V2 regardless of vowel quality. Therefore, hiatus resolution targets V1 more than V2. But the results on vowel position and quality dismiss these expectations; vowel quality has an effect on hiatus resolution. Equally, HYPOTHESIS VI, which states that subjects judge as correct deletion of V1 more often than deletion of V2 and reaction times for phonetic inputs with V1 deletion will be shorter than those for V2 deletion, regardless of vowel quality, is also dismissed.

Overall, the quality of the vowels involved in the sequence does indeed influence its behavior at the phonetic level. However, the seemingly influence of vowel position on hiatus resolution may be the byproduct of other factors interacting on this phenomenon. Take, for instance, the fact that in a vowel sequence across word boundaries, V1 position corresponds to (first-)word final segments information, which is more disposable in terms of information retrieval (cf. section 2.1.2.2) than (second-) word initial segment, in V2 position. Vowel quality seems, thus, a more relevant factor than vowel position in the choice of the strategy that will resolve hiatus.

The results in this double experiment suggests that more sonorous or more marked vowels (/a/ and /o/) have longer duration and resist hiatus resolution more often than less sonorous or less marked vowels (/e/). Thus, for instance, vowel sequence /ao/ in *ninguna oferta* will resist hiatus more often than vowel sequences /ae/ and /oe/ in *casa enorme* and *esfuerzo enorme* respectively or /ea/ and /eo/ in *doce amigos* and *clase obrera* respectively (refer to the example hierarchy in 36 above). If less sonorous and less marked vowels induce hiatus resolution more often, then deletion instances should also be greater than hiatus for vowel sequences containing those vowels. However, the actual results of the experiment show a lower percentage of deletion instances with the vowel /e/, the least sonorous and least marked of the three vowels in this case. This counterfact can only suggest that quality has a partial effect in hiatus resolution, in the sense that there are other factors as well as vowel quality that interact in the phenomenon of hiatus resolution.

5.1.2. Word boundaries

Moving on to contexts of hiatus resolution across word boundaries, the results of the double experiment are highly significant with respect to this prosodic factor. First, vowel sequences across word boundaries are shorter than sequences within word boundaries. Second, hiatus is maintained more often within word boundaries than across word boundaries; but if resolved, then acoustic diphthongization is the preferred strategy within word boundaries, whereas across word boundaries coalescence and deletion occur more often. Third, deletion across word boundaries is judged as correct more often than within word limits, and the reaction times for those responses are also shorter across word boundaries. These results robustly confirm HYPOTHESIS II, which states exactly what the results show: more hiatus resolution –shorter duration- across word boundaries than within the lexical word. Equally, the results also confirm HYPOTHESIS VII: subjects judge as correct deletion across word boundaries more often than deletion within word boundaries, and their reaction times are shorter.

5.1.3. Word type

Focusing on vowel sequences across word boundaries, the effects of a third factor is introduced in the analysis in the double experiments: the type of word that combine the vowel sequences at the word limit. This factor includes content+content, function+content and content+function word pairs. HYPOTHESIS III predicted that hiatus resolution would target mostly vowel sequences in function+content word combinations, less in content+function and far less in content+content. The production task, however, shows different results: (i) function+content contexts do not show statistically significant results, even if they do not suggest to maintain hiatus more than other word combinations; and (ii) vowel sequences in content+content contexts resolve hiatus via coalescence and deletion mostly. The results reveal that content+content word combinations are significantly shorter in terms of duration than the other two; they also show the highest percentage of instances of coalescence and deletion. Even though the results are not significant, they do suggest a possible trend if durational reduction implies more chances for hiatus resolution.

No further relevant results can be obtained from the production experiment, but the lexical decision results reveal significantly shorter reaction times of responses judged as correct in instances of deletion involving content+function words. Moreover, although not statistically significant, the results also suggest that deletion in vowel sequences of function+content word pairs is judged as correct less often and subjects' responses as correct show longer reaction times than other word combinations. In all, results run against HYPOTHESIS III, since it predicted that function+content word pairs would show shorter durations and resolve hiatus more often than content+function; and content+function word pairs, in turn, resolve hiatus more often than content+content. But this prediction is not consistent with the results, since subjects show shorter durations for content+content than for other word combinations and the highest percentage of coalescence and deletion takes place in that context. Added to that, the results from the lexical decision experiment confirm the latter.

5.1.4. Syllable type

In order to analyze the effect of syllable type, the study focused on content+content word combinations and compared the realization of vowel sequences with and without a coda. Sequences with a coda are significantly shorter than codaless ones and they resolve hiatus via coalescence and deletion more often, whereas codaless sequences prefer to maintain hiatus or to resolve it via acoustic diphthongization. These results run contrary to HYPOTHESIS IV, which predicted codaless vowel sequences to be better contexts for hiatus resolution. The results from the production task based on the effect of syllable type are supported by the analysis of the lexical decision task, in which deletion in phonetic inputs of vowel sequences with a coda are judged as correct more often and their reaction times are shorter than in phonetic inputs without a coda. These results also run contrary to HYPOTHESIS IX: all of these significant results strongly confirm the idea that vowel sequences followed by a coda are better contexts for hiatus resolution, whereas codaless vowel sequences tend to maintain hiatus more often.

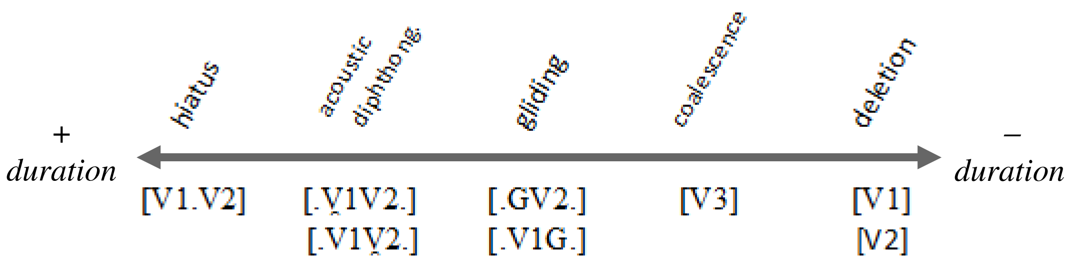
5.1.5. Coda type

To finish the report on the results of the study, a further exploration was done for those vowel sequences followed by a coda, by analyzing the effect of the coda type. The overall results are not statistically significant in many cases, but suggest a trend that reveals interesting results. First, a relevant effect on hiatus resolution is suggested between a general group of obstruent codas and the apico-alveolar sibilant /s/ (which is also an obstruent): obstruent codas (excluding the /s/) show the longest duration and a significantly greater percentage of hiatus and acoustic diphthongization instances than the rest of coda types; whereas vowel sequences with a /s/ coda resolve mainly through deletion. HYPOTHESIS V is, thus, confirmed. It predicted that obstruent codas would favor longer vowel sequences and therefore would rather maintain hiatus, as opposed to other coda types; and /s/ codas would motivate durational reduction and therefore hiatus resolution. This result is further supported by the trend observed in the analysis on judgment of correct responses, in which vowel sequences with hiatus resolution followed by obstruents are judged as correct less often than vowel sequences with hiatus resolution followed by the rest of the coda types. Moreover, the /s/ coda shows the highest percentage of responses judged correct when deletion applies. However, no concluding information was obtained regarding the reaction times of the responses judged as correct under the effect of /s/ coda. Thus, HYPOTHESIS Xa (subjects judge more correct deletion of vowel sequences with obstruent codas than nasal and liquid codas; and their reaction times are shorter in contexts with obstruent codas than in nasal or liquid codas) was dismissed, whereas HYPOTHESIS Xc (subjects judge as correct and their reaction times are shorter in deletion of a vowel sequence followed by a /s/ coda) was confirmed.

5.2. Findings and contributions

The present research provides several important contributions to the study of vowel reduction and hiatus resolution, both directly through the findings described above and indirectly through implications from the analyses. First, the acoustic study recorded clear instances of the various strategies of hiatus resolution that were presented through a series of spectrograms in chapter 2. Thus, the process of hiatus resolution involves various strategies in which durational variation and formant frequency changes in the vowels are observed. Four strategies are proposed for hiatus resolution: acoustic diphthongization, gliding, coalescence and deletion. However, the results from the experiment suggest a binary division of these strategies. Many of the results that have been observed for hiatus throughout the different analyses have also been observed for acoustic diphthongization and gliding, whereas coalescence and deletion often behaved similarly. Thus, this binary division of the strategies of hiatus resolution groups together acoustic diphthongization and gliding on the one hand and coalescence and deletion on the other. The former group maintains two vocalic segments, even though duration of the vowel sequence is reduced. The latter group resolves hiatus through the realization of a single vocalic segment instead of two (further durational reduction, which requires resyllabification). Thus, although hiatus resolution is speaker dependant, the four strategies act in a gradient manner, which is mainly determined by the durational variability of the vowel sequence at the phonetic output. In other words, hiatus requires full vowel durations; but as duration in production decreases, acoustic diphthongization or gliding can apply; further durational reduction is motivated by coalescence or deletion.

Figure 21
The gradient nature of hiatus resolution in terms of vowel duration



The choice of selecting acoustic diphthongization or gliding is revealed by the observation of the effects of vowel quality. Gliding occurs when the target vowel rises to a high semivowel, or glide; whereas acoustic diphthongization takes place when the target vowel does not change into a glide (the *paellera* case, refer to table 2). The instances of gliding provided throughout this dissertation were only the result of a number of tokens in the study that contained a palatal consonant following the vowel sequence. Thus, the preceding vowel assimilated to that position. Still, this dissertation is mainly concerned with vowel sequences of non-high vocalic segments, that would not rise to what is traditionally known as diphthongization (involving high vowels). The choice between coalescence or deletion needs further exploration. No conclusions were revealed in this study that can distinguish a preference for one strategy over another.

Another goal of this dissertation was to provide evidence to show the effect of five segmental and prosodic factors on the behavior of vowel sequences in hiatus. The motivation for this line of analysis was to cover a larger range of factors interacting with each other, which was not provided in previous literature. Some of these factors have proved to have a great effect on the speaker's choice of producing hiatus or resolving it. Although hiatus resolution targeting V1 position has widely been supported throughout the literature, this study shows the interaction of vowel position with vowel quality.

Word boundaries and word type also affect hiatus resolution. Indeed, hiatus resolution strategies are often applied in vowel sequences across word boundaries, but within the word limits, the speaker prefers to maintain the canonical distribution of the vowels. Added to that, in contexts across word boundaries, hiatus resolution seems to affect vowel sequences in function+content word combinations the least. In turn, vowel sequences in content+content and content+function word combinations allow hiatus resolution more often. These observations support the claim that hiatus resolution is a phonetic process, left at the choice of the speaker to produce it or not. However, certain contexts have been proved to be better triggers than others, such as the ones discussed above or the ones in the paragraph below.

The existence of a coda following the vowel sequence also influences greatly the realization of hiatus resolution. The results demonstrated that codaless sequences resolve hiatus less often than sequences with a coda. Added to that, among the various coda groups in the language, obstruent codas block hiatus resolution more often than sonorant codas. The obstruent group does not include the apico-alveolar sibilant, which is detached from that coda group showing a radically different behavior. The /s/ coda does not block hiatus resolution and, moreover, allows deletion more often than any other coda groups. These facts confirm the special status of this consonant within the phonological consonantal system of the language.

To sum up, this dissertation contributes to the literature of hiatus resolution in two ways: by providing factual support of the various strategies that resolve hiatus and by confirming the mutual effect of a number of phonological factors, which in previous literature had mostly been studied in isolation. These phonological cues predict to some extent the possibility of hiatus resolution.

5.3. Implications and issues for further research

Due to the large scope of the experimental design throughout this dissertation, the research had to be limited to a number of specific analyses, factors and measurements. After concluding them, the results beg for further investigation of the variables involved in the double experiment provided here. First, further research needs to be done on the effect of vowel position and its interaction with vowel quality: although it has been shown that vowel quality does have an effect on hiatus resolution and not only vowel position (V1 position) motivates it, it is not yet defined which specific vowel qualities apply in which contexts. Second, the analyses on word type, syllable type and coda type only included a subgroup of the vowel sequences from table 2 (across word boundaries). A future research should include these variables in all possible contexts.

Throughout this dissertation, a close connection is made between the interaction of articulatory duration in production of vowel sequences and phonological structure (vowel position, syllable type, word boundaries, etc.). The effect of five phonological contexts is studied on hiatus resolution, which occurs in Spanish at the phonetic level. On the one hand, it is concluded that durational reduction of the vowel sequence motivates that phenomenon called hiatus resolution. Incidentally, those five phonological contexts seem to allow more or less durational reduction. Thus, it seems reasonable to suggest that hiatus resolution can be explained as a phonetically-grounded phonological phenomenon. It is claimed that in Spanish there exists a quasi-predictable pattern of vowel reduction which has specific effects within and across word boundaries, and which is determined by phonological patterns such as the syllabic structure or the position of stress on each word; these are factors involved in the interaction of articulatory, acoustic and perceptual correlates of speech sounds. Hiatus resolution involves discrete phonological categories that appear in constant relation with gradient phonetic parameters, shared among speakers in real time. Phonology is primarily the study of a categorical system with a specific structure and based on lexical contrasts, shared among speakers. Phonetics, in turn, describes gradient phenomena of production and perception in real time which are speaker dependant. However, it is arresting to note that hiatus resolution shows an interaction of both disciplines. Thus, a remaining question for further research involves the status of the phonology in phonetic interface.

Vowel reduction in unstressed syllables is a topic of research within a long standing research tradition (from Lindblom 1963 to Flemming 2004), which has contributed to set the bases for both an *integrated* theory as well as a *modular* theory of phonetics and phonology (Howe & Pulleyblank 2001). In a modular theory, perceptual factors on durational reduction, that is, the relevance of "reduced perceptibility" as the leading force in durational reduction, would determine the phonological arrangement of vowel sequence as possible candidates for hiatus resolution. On the contrary, in an integrated theory, phonological constraints, independent of each other, affect patterns of hiatus resolution motivated by articulatory timing and perceptual restrictions. Crucially, this dissertation has provided data that support an integrated approach to Phonetics and Phonology in the lines of research of Ohala (1990, 1997). Indeed, phonological cues of vowel sequences affect their production in hiatus (as shown throughout the production experiment reported in chapters 2 and 3). Added to that, the lexical production experiment in chapter 4 suggests the interaction of phonetic outputs of vowel sequences in hiatus with their intuitions about the phonological structures of those vowel sequences, based on their perceptions. Specifically, a study by Hualde, Simonet & Torreira (2008) focuses on the interaction of production and perception of non-high vowels, based on the fact that shorter vowels may be perceived as higher than what they really are; therefore they are produced as such. That is to say mid vowel /e/ may be perceived in a vowel reduced contexts as higher, and that is reason enough to produce it as a high(er) vowel. Further research on contexts that favor vowel reduction should contribute to the development of the integrated approach to Phonetics and Phonology.

APPENDIX A

SENTENCES FOR THE PRODUCTION EXPERIMENT

List of sentences for the production task: the tokens and their English translation are underlined. The vowel sequences in each token are boldfaced; for the sequences with a coda (refer to section 2.1.2.5) the consonant representing the coda has also been boldfaced.

1. Dicen que vivía en la cas**a e**norme que se quemó la semana pasada

   'They say he used to live in the huge house that burnt last week'

2. Ha comenzado un nuev**o es**tudio sobre la literatura del Siglo de Oro

   'He has started a new study on the literature of the Golden Age'

3. Se chocaron porque todo estab**a os**curo y no se podían ver

   'They had a crash because everything was dark and it wasn't possible to see'

4. Pablo llega mañan**a o** pasado por la tarde, pero no recuerdo bien

   'Pablo arrives tomorrow or the day after in the afternoon, but I don't remember exactly'

5. He encontrado est**e ar**tículo en el periódico de hoy

   'I have found this article in todays' newspaper'

6. Es de una tribu m**ao**rí polinesa

   'He is from a polinesian maori tribe'

7. Dile que traiga otr**a on**cena mañana

   'Tell him to bring another group of eleven[*] tomorrow'

8. No conoce l**a e**dad que tienen sus hijos

   'He doesn't know the age his children are'

9. No toques est**e om**bligo que hay que desinfectarlo primero

   'Don't touch this belly button that it has to be disinfected first'

10. Ayer leí en el periódico que la clas**e o**brera representa el 80% de la población

    'Yesterday I read in the news that the working class represents 80% of the population'

11. Estoy buscando trabajo, pero como no salga ningun**a o**ferta esta semana me matriculo otra vez en la universidad

    'I'm looking for a job, but if no offer shows up this week I will enrol again in university'

12. Viajará desd**e As**turias hasta Madrid en bici

    'I will travel from Asturias to Madrid by bike'

13. Si se c**oa**gula la sangre puede haber problemas

    'If blood coagulates there can be problems'

14. El documental se llama "El Art**e An**tiguo de Roma"

    'The documentary is called "Rome's Antique Art"'

15. ¿Qué se l**e o**frece a usted, señorita?

    'How may I help you, Madam?'

16. Diplomática venezolana sient**e or**gullo de haber sido expulsada de EEUU

    'Venezuelan diplomat feels proud for being expelled from the USA'

[*] As in *dozen* for a group of twelve.

17. El lunes que viene nos vemos, y hast**a en**tonces trabajas en tu proyecto. ¿Vale?

    ‘Next Monday we see each other, and until then you work on your project. OK?’

18. ¿Prefieres viajar por air**e o** mar cuando vas de vacaciones?

    ‘Do you prefer to travel by air or sea when you go on holidays?’

19. Sólo sale si l**e a**yuda su hija, si no, puede pasarse toda la semana en casa

    ‘He only goes out if his daughter helps him, otherwise he can spend the whole week at home’

20. Han montado un **tea**trillo de marionetas en dos días

    ‘They have created a small puppet show in two days’

21. Con las ventajas de un moment**o ac**tual como este, es preferible que lo hagamos ya

    ‘With the advantages of a present moment like this one, it is preferable that we do it right away’

22. De camino a Madrid párate en el restaurante que te digo, que tienen el mejor cerd**o a**sado de la región

    ‘On the way to Madrid stop at the restaurant I’m telling you about, they have the best roasted pork in the region’

23. Si quiere irs**e a** casa que se coja un taxi, que yo no soy su chófer

    ‘If he wants to go home he can take a taxi, I’m not his driver’

24. Hacer la tesis requiere un esfuerz**o e**norme y en momentos de tensión no conviene desinteresarse

    ‘Doing the dissertation requires a great effort and in moments of tension it is not advisable to loose interest’

25. Déjate de tanta **teo**ría y pasa a la práctica ya

    ‘Stop it now with so much theory and move on to the practice right away’

26. Parece como si una noch**e os**cura nos envolviera

    ‘It is as if a dark night covered us’

27. Vete hasta la Plaz**a Es**paña y allí gira a la derecha, por la avenida Central

    'Go up to the Spanish square (name) and there turn right, on the Central avenue'

28. Ana ha conseguido una foto de cuerp**o en**tero de Brad Pitt

    'Ana has obtained a full-body picture of Brad Pitt'

29. Compra otr**a or**quídea porque esta está muriéndose

    'Buy another orchid because this one is dying'

30. Si vas por l**a o**rilla durante media hora puedes llegar hasta el siguiente pueblo

    'If you go along the sea-shore for half an hour you can get to the next town'

31. El romano Marc**o An**tonio es conocido por su lucha contra los partos

    'The Roman Marc Anthony is known for his battle against the parthians'

32. La peli que vimos el curso pasado no se llamaba "los doc**e a**migos" sino "los tres amigos"

    'The movie we saw last course was not called "the twelve friends" but "the three friends"'

33. Con la p**ae**llera grande pueden hacerse 12 raciones

    'With the big paella-pan one can make 12 servings'

34. Vemos si l**o a**cepta como válido y luego decidimos lo que hacemos

    'We'll see whether he accepts it as valid and then we'll decide what we do'

35. Aunque hayan pasado los años, tiene el mism**o as**pecto que cuando nos conocimos

    'Even if years have gone by, he has the same appearance than when we met'

36. El mes pasado hubo un atentado a man**o ar**mada cerca de esa ciudad

    'Last month there was an hand armed attack near this city'

37. El libro se titula "de l**o e**terno lo mejor"

    'The book is entitled "the best from the eternal"'

38. El caballo se recuperó en la carrer**a oc**tava y ganó el resto
‘The horse recovered in the eighth race and won the rest’

39. Todo consumidor tiene dónd**e op**tar a la hora de comprar
‘All consumers have where to choose at the buying time’

40. Es muy altiva y va con la cabez**a er**guida a todas partes
‘She is very arrogant and goes everywhere with her head up straight’

41. El poeta utiliza un lenguaj**e ac**tual claro y fácil de entender
‘The poet uses a clear and easy to understand up-to-date language’

42. En la fiesta de ayer hubo vin**o a** raudales durante toda la noche
‘In yesterday’s party there was wine gushing out throughout the night’

43. El **roe**dor que me gusta es Speedy González
‘The rodent that I like is Speedy Gonzalez’

APPENDIX B

PHONETIC INPUTS FOR THE LEXICAL DECISION EXPERIMENT

1. Phonetic inputs

	Tokens	*Phonetic form*	*Phonetic inputs with V_1 deletion*	*Phonetic inputs with V_2 deletion*
1	paellera	[p**ae**ʝeɾa]	[p**e**ʝeɾa]	[p**a**ʝeɾa]
2	maorí	[m**ao**ɾi]	[m**o**ɾi]	[m**a**ɾi]
3	teatrillo	[**tea**triʝo]	[**ta**triʝo]	[**te**triʝo]
4	teoría	[**teo**ɾia]	[**to**ɾia]	[**te**ɾia]
5	coagula	[k**oa**γula]	[k**a**γula]	[k**o**γula]
6	roedor	[**roe**δor]	[**re**δor]	[r**o**δor]
7	casa enorme	[kas**ae**norme]	[kas**e**norme]	[kas**a**norme]
8	ninguna oferta	[ningun**ao**ferta]	[ningun**o**ferta]	[ningun**a**ferta]
9	doce amigos	[doθ**ea**miγos]	[doθ**a**miγos]	[doθ**e**miγos]
10	clase obrera	[klas**eo**breɾa]	[klas**o**breɾa]	[klas**e**breɾa]
11	cerdo asado	[θerδ**oa**saδo]	[θerδ**a**saδo]	[θerδ**o**saδo]
12	esfuerzo enorme	[esfuerθ**oe**norme]	[esfuerθ**e**norme]	[esfuerθ**o**norme]
13	la edad	[**lae**δaθ]	[**le**δaθ]	[**la**δaθ]
14	la orilla	[**lao**ɾiʝa]	[**lo**ɾiʝa]	[**la**ɾiʝa]
15	le ayuda	[**lea**ʝuδa]	[**la**ʝuδa]	[**le**ʝuδa]
16	le ofrece	[**leo**freθe]	[**lo**freθe]	[**le**freθe]
17	lo acepta	[**loa**θepta]	[**la**θepta]	[**lo**θepta]
18	lo eterno	[**loe**terno]	[**le**terno]	[**lo**terno]

19	mañana o (pasado)[17]	[maɲan**ao**pasaδo]	[maɲan**o**pasaδo]	[maɲan**a**pasaδo]
20	irse a (casa)	[irs**ea**kasa]	[irs**a**kasa]	[irs**e**kasa]
21	aire o (mar)	[ajɾ**eo**mar]	[ajɾ**o**mar]	[ajɾ**e**mar]
22	vino a (raudales)	[bin**oa**rauδales]	[bin**a**rauδales]	[bin**o**rauδales]
23	hasta entonces	[ast**ae**ntonθes]	[ast**e**ntonθes]	[ast**a**ntonθes]
24	otra oncena	[otr**ao**nθena]	[otr**o**nθena]	[otr**a**nθena]
25	arte antiguo	[art**ea**ntiγwo]	[art**a**ntiγwo]	[art**e**ntiγwo]
26	este ombligo	[est**eo**mbliγo]	[est**o**mbliγo]	[est**e**mbliγo]
27	Marco Antonio	[mark**oa**ntonjo]	[mark**a**ntonjo]	[mark**o**ntonjo]
28	cuerpo entero	[kwerp**oe**nteɾo]	[kwerp**e**nteɾo]	[kwerp**o**nteɾo]
29	cabeza erguida	[kaβeθ**ae**rγiδa]	[kaβeθ**e**rγiδa]	[kaβeθ**a**rγiδa]
30	otra orquidea	[otr**ao**rkiδea]	[otr**o**rkiδea]	[otr**a**rkiδea]
31	este artículo	[est**ea**rtikulo]	[est**a**rtikulo]	[est**e**rtikulo]
32	siente orgullo	[sjent**eo**rγuʝo]	[sjent**o**rγuʝo]	[sjent**e**rγuʝo]
33	mano armada	[man**oa**rmaδa]	[man**a**rmaδa]	[man**o**rmaδa]
34	Plaza España	[plaθ**ae**spaɲa]	[plaθ**e**spaɲa]	[plaθ**a**spaɲa]
35	estaba oscuro	[estaβ**ao**skuɾo]	[estaβ**o**skuɾo]	[estaβ**a**skuɾo]
36	desde Asturias	[desδ**ea**stuɾjas]	[desδ**a**stuɾjas]	[desδ**e**stuɾjas]
37	noche oscura	[notʃ**eo**skuɾa]	[notʃ**o**skuɾa]	[notʃ**e**skuɾa]
38	mismo aspecto	[mism**oa**spekto]	[mism**a**spekto]	[mism**o**spekto]
39	nuevo estudio	[nueβ**oe**stuδjo]	[nueβ**e**stuδjo]	[nueβ**o**stuδjo]
40	carrera octava	[kareɾ**ao**ktaβa]	[kareɾ**o**ktaβa]	[kareɾ**a**ktaβa]
41	lenguaje actual	[lenγwax**ea**ktwal]	[lenγwax**a**ktwal]	[lenγwax**e**ktwal]
42	donde optar	[dond**eo**ptar]	[dond**o**ptar]	[dond**e**ptar]
43	momento actual	[moment**oa**ktwual]	[moment**a**ktwual]	[moment**o**ktwual]

[17] In contexts where the vowel sequence appears in function+contents words, the vowel sequence results in final position. In order to avoid that in the lexical experiment, the following word was also included, which is illustrated in the appendix with a parenthesis. Thus, the phonetic inputs correspond to the following:

mañana o (pasado)	'tomorrow or (the day after)'
irse a (casa)	'To go to (home)'
aire o (mar)	'Air or (sea)'
vino a (raudales)	'Wine in (streams)', ('wine gushing')

2. Fillers

	Non-words	*Real words*
1	docipedo	mismoamigo
2	territerio	hastaahora
3	jarriplan	lamesa
4	estaisturas	airepuro
5	partestorada	chimichanga
6	casiunila	miscelaneo
7	letan	pedroatiende
8	dalipera	cogefrutos
9	valiamina	momentito
10	miniamino	lenguaindia
11	manomina	parteentera
12	vinoanispo	traetelvino
13	palilotelo	paleolito
14	latipo	Latina
15	loameco	dondearmaba
16	orquiplaste	grandeber
17	multiaera	podium

REFERENCES

AGUILAR, Lourdes. 1997. *De la Vocal a la Consonante*, Universidad de Santiago de Compostela.

AGUILAR, Lourdes. 1999. "Hiatus and diphthong: acoustic cues and speech situation differences". *Speech Communication* 28. 57-74.

AGUILAR, Lourdes. 2003. "Effects of prosodic and segmental variables on vowel sequences pronunciation in Spanish". Proceedings of the 15th International Congress of Phonetic Science, Barcelona. 2111-2114.

AGUILAR, Lourdes and María MACHUCA. 1995b. "Pragmatic factors affecting the phonetic properties of diphthongs". Proceedings of the 4th European Conference on Speech Communication and Technology, Madrid. 2251-2254.

ALARCOS LLORACH, Emilio. 1974 (4th ed.). *Fonología Española*, Madrid: Gredos.

ALBA, Matthew. 2006. "Accounting for variability in the production of Spanish vowel sequences". Proceedings of the 9th Hispanic Linguistic Symposium, Somerville, MA: Cascadilla Proceedings Project. 273-285.

ALBA, Matthew. 2005. *Hiatus Resolution between Words in New Mexican Spanish: a Usage-Based Account*, PhD dissertation, University of New Mexico.

BAKOVIĆ, Eric. (2006). "Hiatus resolution and incomplete identity". *Optimality-Theoretic Studies in Spanish Phonology*, (eds.) S. Colina and F. Martínez-Gil, John Benjamins. 62-73.

BARNES, Jonathan A. 2002. *Positional Neutralization: a Phonologization Approach to Typological Patterns*, PhD dissertation, University of California, Berkeley.

BARRUTIA, Richard and Armin SCHWEGLER. 1994. *Fonética y Fonología Espanolas: Teoria y Práctica*. New York, NY: Wiley.

BELL, Allan, Jason M. Brenier, Michelle Gregory, Cynthia Girand and Dan Jurafsky. 2009. “Predictability effects on durations of content and function words in conversational English”. *Journal of Memory and Language* 60, Amsterdam: Elsevier. 92-111.

BORZONE DE MANRIQUE, Ana Mª. 1980. *Manual de Fonética Acústica*, Buenos Aires: Hachette.

BURZIO, Luigi. 2007. “Phonology and phonetics of English stress and vowel reduction”. *Language Science 29*, Amsterdam: Elsevier. 154-176.

BYBEE, Joan. 2001. *Phonology and Language Use*. Cambridge University Press.

BYBEE, Joan and Joanne SCHEIBMAN. 1999. “The effect of usage on degrees of constituency the reduction of *don't* in English”. *Linguistics* 37. 575-596.

BYBEE, Joan, Revere PERKINS and William PAGLIUCA. 1994. *The Evolution of Grammar: Tense, Aspect and Modality in the Languages of the World*, University of Chicago Press.

BYRD, Dani and Cheng Cheng TAN. 1996. “Saying consonant clusters quickly”. *Journal of Phonetics 24, 2: 263-282.*

CABRÉ, Teresa and Pilar PRIETO. 2003. “Vowel contact resolution across word boundaries in Catalan”. Proceedings of the 15th International Congress of Phonetic Science, Barcelona. 1687-1690.

CABRÉ, Teresa and Pilar PRIETO. 2004. “Prosodic and analogical effect in lexical glide formation in Catalan”. *Probus 16*. 113-150.

CARREIRA, María. 1991. “The alternating diphthongs in Spanish: a paradox revisited”. *Current Studies in Spanish Linguistics*, Georgetown University Press. 407-445.

CASALI, Roderic. 1997. “Vowel elision in hiatus context: which vowel goes?” *Language 73*. 493-533.

CASALI, Roderic. 1998: *Resolving Hiatus*, New York: Garland Publishing.

CHITORAN, Ioana and José Ignacio HUALDE. 2007. “From hiatus to diphthong: the evolution of vowel sequences in Romance”. *Phonology 24*. 37-75.

COLANTONI, Laura and Anna LIMANNI. 2010. “Where are hiatuses left? A comparative study of vocalic sequences in Argentine Spanish”. *Romance Linguistics 2008: Interactions in Romance*, Philadelphia, PA: John Benjamins. 23-38.

COLINA, Sonia. 2009. *Spanish Phonology: A Syllabic Perspective*, Washington D.C.: Georgetown University Press.

CROSSWHITE, Katherine. 1999. *Vowel Reduction in Optimality Theory*, PhD dissertation, University of California, Los Angeles.

CROSSWHITE, Katherine. 2000. “Sonority-driven reduction”. Proceedings of the Berkeley Linguistic Society 26, University of California, Berkeley. 77-88.

DAUER, Rebecca. 1983. “Stress-timing and syllable-timing reanalyzed”. *Journal of Phonetics* 11. 51-62.

DIAZ-CAMPOS, Manuel. 2000. “The phonetic manifestation of secondary stress in Spanish”. *Hispanic Linguistics at the Turn of the Millennium: Papers from the 3rd Hispanic Linguistic Symposium*, (eds.) H. Campos, E. Herburger, A. Morales-Front and T. J. Walsh, Somerville: Cascadilla Press. 49-65.

D’INTRONO, Francesco, Enrique DEL TESO, and Rosemary WESTON. 1995. *Fonética y Fonología Actual del Español*, Madrid: Cátedra.

ESGUEVA, Manuel Agustín. 1999. “Vocales en Contacto: La Elisión”. *Lengua y Discurso. Estudios Dedicados al Profesor Vidal Lamíquiz*, (eds.) P. Carbonero-Cano, M. Casado Velarde and P. Gómez Manzano, UNED. 287-299.

FLEMMING, Edward. 2004. “Contrast and perceptual distinctiveness”. *Phonetically Based Phonology*, (eds.) B. Hayes, R. Kirchner and D. Steriade, Cambridge University Press. 232-276.

FLEMMING, Edward. 2005. “A phonetically-based model of phonological vowel reduction” Ms, MIT.

FOURAKIS, Marios. 1991. “Tempo, stress, and vowel reduction in American English”. *Journal of the Acoustic Society of America* 90. 1816-1827.

GARRIDO, Marisol. 2008. *Diphthongization of Non-HIgh Vowel Sequences in Latin American Spanish*, PhD. diss., University of Illinois at Urbana-Champaign.

GAY, Thomas. 1978. "Effect of speaking rate on vowel formant movements", *Journal of the Acoustical Society of America* 63, 223-230.

GONZALEZ, Carolina. 2003. *The Effect of Stress and Foot Structure on Consonantal Processes*, PhD dissertation, University of Southern California.

GOW Jr., David W., Janis MELVOLD and Sharon MANUEL. 1996. "How word onsets drive lexical access and segmentation: evidence from acoustics, phonology and processing", In *4th International Conference of Spoken Language Processing*, Philadelphia, PA. 66-69.

HARRIS, James W. 1969: *Spanish Phonology*, Cambridge, MA: MIT Press.

HARRIS, James. 1983. *Syllable Structure and Stress in Spanish: a Nonlinear Analysis*, Cambridge, MA: MIT Press.

Hayes, Bruce, Robert KIRCHNER and Donca STERIADE (eds.) 2004. *Phonetically Based Phonology*, Cambridge University Press.

HOWE, Darin and Douglas PULLEYBLANK. 2001. “Patterns and timing of glottalisation”. *Phonology* 18. 45-80.

HUALDE, José Ignacio. 1991. “On Spanish syllabification”. *Current Studies in Spanish Linguistics*, (eds.) H. Campos and F. Martínez-Gil, Washington DC: Georgetown University Press. 475-493.

HUALDE, José Ignacio. 2004. “Quasi-phonemic contrast in Spanish”. Proceedings of the 23rd West Coast Conference on Formal Linguistics, (eds.) V. Chand, A. Kelleher, A. Rodríguez and B. Schmeiser, Somerville, MA: Cascadilla Press. 374-398.

HUALDE, José Ignacio. 2005. *The Sounds of Spanish*, Cambridge : Cambridge University Press.

HUALDE, José Ignacio and Ioana CHITORAN. 2003. “Explaining the distribution of hiatus in Spanish and Romanian”. Proceedings of the 15th International Congress of Phonetic Science, Barcelona. 1683-1686.

HUALDE, José Ignacio and Mónica PRIETO. 2002. "On the diphthong/hiatus contrast in Spanish: some experimental results". *Linguistics* 40. 217-234.

HUALDE, José Ignacio, Miquel SIMONET and Francisco TORREIRA. 2008. "Postlexical contraction of nonhigh vowels in Spanish". *Lingua 118*, Amsterdam: Elsevier. 1906-1925.

HUNG, Henrietta. 1994. *The Rhythmic and Prosodic Organization of Edge Constituents*, Ph.D. dissertation, Brandeis University.

JENKINS, Devin L. 1999. *Hiatus Resolution in Spanish: Phonetic Aspects and Phonological Implications from Northern New Mexican Data*, PhD dissertation, University of New Mexico.

LADEFOGED, Peter. 1993 (3rd ed.). *A Course in Phonetics*, Fort Worth, TX: Harcourt Brace College Publishers.

LEHISTE, Ilse and Gordon E. PETERSON. 1961. "Transitions, glides and diphthongs". *Journal of the Acoustic Society of America 33*. 268-277.

LINDBLOM, Björn. 1963. "Spectrographic study of vowel reduction". *Journal of the Acoustic Society of America* 35. 1773-1781.

LLISTERRI, Joaquim. 1992. Speaking styles in speech research. *ELSNET/ESCA/SALT Workshop on Integrating Speech and Natural Language*, 15-17 July, Dublin, Ireland.

MARTÍNEZ CELDRÁN, Eugenio. 1984. *Fonética*, Barcelona: Teide.

MONROY, Rafael. 1980. *Aspectos Fonéticos de las Vocales Españolas*, Madrid: SGEL.

MORRIS, Richard E. 2002. Coda obstruents and local constraint conjunction in north-central Peninsular Spanish. In Teresa Shatterfield, Christina D. Tortoraand Diana Cresti (eds.), *Current Issues in Romance Languages: selected papers from the 29th Linguistic Symposium on Romance Languages (LSRL)*, Ann Arbor, 8-11 April 1999. Amsterdam: John Benjamins. 207-233 [ROA 383].

NAVARRO TOMÁS, Tomás. 1966 (3rd ed.). *Manual de Entonación Española*, México: Colección Málaga.

NAVARRO TOMÁS, Tomás. 1990 (24th ed.). *Manual de Pronunciación Española*, Madrid: Consejo Superior de Investigaciones Científicas.

NESPOR, Marina and Irene VOGEL. 1986. *Prosodic Phonology*, Dordrecht: Foris.

NÚÑEZ CEDEÑO, Rafael A. and Alfonso MORALES-FRONT. 1999. *Fonología Generativa Contemporánea de la Lengua Española*, Washington DC: Georgetown University Press.

OHALA, John J. 1990. "There is no interface between phonology and phonetics: a personal view". *Journal of Phonetics* 18. 153-171.

OHALA, John J. 1997. "Phonetics in Phonology". Proceedings of the *4th Seoul International Conference in Linguistics*, 11-15 August. 45-50.

QUILIS, Antonio. 1981. *Fonética Acústica de la Lengua Española*, Madrid: Gredos.

QUILIS, Antonio. 1993. *Tratado de Fonología y Fonética Españolas*. Madrid: Gredos.

ROCA, Iggy. 1997. "There are no 'glides', at least in Spanish: and Optimality account". *Probus* 9. 233-265.

ROSENTHALL, Samuel. 1997. *Vowel/Glide Alternation in a Theory of Constraint Interaction*. New York: Garland Publishing.

SANDS, Kathy L. 2004. *Patternings of Vocalic Sequences in the World's Languages*. PhD dissertation, University of California, Santa Barbara.

SCHIERING, René. 2007. "The phonological basis of linguistic rhythm: cross-linguistic data and diachronic interpretation". (work in progress), [http://www.uni-leipzig.de/~schier/].

SELKIRK, Elisabeth. 1984. *Phonology and Syntax*, Cambridge, MA: MIT University Press.

SENTURIA, Martha B. 1998. *A Prosodic Theory of Hiatus Resolution*, PhD dissertation, University of California, San Diego.

SIMONET, Miquel. 2005. "Prosody and syllabification intuitions of [CiV] sequences in Spanish and Catalan". *Prosodies*, (eds.) S. Frota, M. Vigário and M.J. Freitas, Berlin: Mouton de Gruyter. 247-268.

STERIADE, Donca. 1999. "Phonetics in Phonology: the case of laryngeal neutralization". *Papers in Phonology 3 (UCLA Working Papers in Linguistics 2)*, Los Angeles: University of California, Los Angeles. 25-146.

STOCKWELL, Robert, Donald BOWEN and Ismael SILVA-FUENZALIDA. 1956. "Spanish juncture and intonation". *Language* 32, 641-665.

VEIGA, Aleixandre. 2002. *El Subsistema Vocálico Español*, Santiago de Compostela: Universidad de Santiago de Compostela.