VOWELS OF ROMANIAN:

HISTORICAL, PHONOLOGICAL AND PHONETIC STUDIES

A Dissertation

Presented to the Faculty of the Graduate School

of Cornell University

In Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

by

Margaret Elspeth Lambert Renwick

May 2012

VOWELS OF ROMANIAN:

HISTORICAL, PHONOLOGICAL AND PHONETIC STUDIES

Margaret Elspeth Lambert Renwick, Ph. D.

Cornell University 2012

This dissertation investigates the Romanian vowel system from historical, phonological and phonetic perspectives, centering on *marginal contrasts*, in which a sharp distinction between allophones and phonemes is insufficient to capture the relationships among sounds. Study of both morpho-phonological alternations and synchronic phonetics is necessary to understand the forces driving the phonemic system of Romanian, which is under-studied with respect to other Romance languages.

The dissertation first investigates a historically-based phonological question. In the history of Romanian /ɨ/, it is shown that a combination of native phonological processes and borrowings shaped the vowel's distribution, and although /ɨ/ is synchronically phonemic it remains restricted to a small set of phonologically-determined contexts. A quantitative synchronic counterpart to this study describes relative type frequency among Romanian phonemes, and argues that /ɨ/, as well as diphthongs /e̯a/ and /o̯a/, are marginally contrastive in the language. They have very low type frequency, and their distribution can almost be predicted, although minimal pairs demonstrate their status as phonemes. While /ɨ/ lies in a pairwise relationship of marginal contrast with its former allophone /ʌ/, the diphthongs' contrastiveness is reduced by their large role in the morphology.

Turning to the acoustics of the Romanian vowel system, a phonetic study shows the positioning of monophthongs and diphthongs in the Romanian vowel space, as well as their durational characteristics. The central vowels /ɨ/ and /ʌ/ are shown to

be acoustically distinct; additionally, two pilot perceptual experiments investigate the relationship between these vowels' marginal contrastiveness and their perception. A second study, which compares coarticulation in Romanian and Italian, examines vowels' characteristics as a function of phonetic context. Disparities in magnitudes of coarticulation across contexts and languages are argued to parallel phonological differences between the two languages. These differences additionally have implications for models of the relationship between inventory size and acoustic vowel space.

The dissertation emphasizes the interrelations between phonetics and phonology, and demonstrates the influence of morphology on phonological contrasts and phonetic processes in Romanian. In conclusion, a model is proposed for comparing the relative influences of lexical contrast, relative frequency, and morphology on the members of a phonological system.

BIOGRAPHICAL SKETCH

Margaret Elspeth Lambert Renwick was born in New Brunswick, New Jersey where she lived until age 4, when her family moved to Oxford, Ohio. In the second grade, she chose the nickname Peggy. She graduated from Talawanda High School and attended Wellesley College, where she double-majored in Cognitive & Linguistic Sciences and Italian Studies and graduated *magna cum laude* in 2004. During that time she also began her investigations of phonetics and phonology while working in the Speech Communication Group at MIT. Nourishing a passion for cave exploration, she lived and worked in (and underneath) the Black Hills of South Dakota and in Kentucky before entering the Linguistics Ph.D. program at Cornell University in 2006.

Dedicated to the Lambert and Renwick families,

who share with me an intellectual tradition and a passion for exploration.

ACKNOWLEDGMENTS

Earning a Ph.D. is a process, and while in the end only the candidate can complete it, I cannot imagine undertaking it alone. I offer my gratitude to those who have helped me arrive at this point.

My Special Committee has provided not only guidance and support, but also an academic framework into which to grow, and I thank each member for her or his contributions during my time at Cornell.

I thank Abby Cohn for her willingness to work closely with me and to provide the kind of feedback I needed throughout my career at Cornell. I am profoundly grateful for all the roles she has filled for me, among them advisor, employer, and friend. With Abby's advice and example, I am learning the value of *proper framing* in all aspects of my life.

Draga Zec has been an integral part of my linguistics career since I arrived at Cornell, and she has offered invaluable methodological advice and helpful feedback on my dissertation, whose sometimes disparate topics are more richly linked thanks to Draga's deep fonts of knowledge.

To Carol Rosen goes credit for the initial questions that inspired this dissertation; additionally she facilitated my fieldwork in Romania through her friendships there, and taught me the basics of Romanian phonology and grammar. I am immensely honored to have worked with Carol, who simply put is the best teacher I've ever had.

Ioana Chiţoran has provided expert methodological and conceptual support for the experimental portions of this dissertation, working tirelessly and often across great distances to help me develop stimuli for the production and perception studies. I am

grateful for her enthusiasm towards my work, encouraging new perspectives on questions she raised in her own dissertation at Cornell.

Sam Tilsen has greatly improved the empirical value of my dissertation with his deep knowledge of statistical analysis. I thank him for setting the experimental work on firmer ground, and for looking at the results from different angles in order to determine the full extent of their implications for linguistic modeling.

Each member of my Special Committee has made vital contributions to this dissertation, and has helped guide me through the Ph.D. process and towards the next steps in my career. Besides these five official advisors, I thank Stefanie Shattuck-Hufnagel, who has patiently mentored, encouraged and inspired me since I worked with her at MIT's Speech Communication Group. I also thank Michael Wagner for advising me during my first years at Cornell. Outside of my committee, I have been grateful for the departmental support offered by Angie Tinti, Sheila Haddad, and Phani Love; and within the Phonetics Lab, my experimental work was made much smoother by the helpful presence of Eric Evans.

My fieldwork in Romania would not have been possible without support from the Mario Einaudi Center for International Studies and the Graduate School at Cornell University, which provided funding for research travel and summer language instruction at Indiana University's SWSEEL program. I could not have had a successful trip to Romania without assistance from the Faculty of Letters at Babeş-Bolyai University in Cluj-Napoca. I am profoundly grateful for the warm and generous welcome of Ştefan, Liana and Andy Oltean, the Cîmpean family, and the tireless efforts of Adriana Todea. I also thank the faculty and staff of the Alpha Center for Modern Languages for hosting me, and the staff of the Erasmus program in Cluj for inviting me on their cultural excursions. Of course, the experiments in this dissertation could not have taken place without the sixty-odd cheerful and patient

native speakers of Romanian and Italian who participated. Among these I recognize especially Catalina Iricinschi, who enthusiastically returned to the Phonetics Lab each time a new study was hatched, and also collected some of the initial data during a trip home.

My years at Cornell have been enriched by time spent with colleagues and friends in Ithaca, the Linguistics and Romance Studies Departments, and the Cornell Outing Club. Ben Currens has been there to support and encourage me at each step of the way, and I thank him for believing in me. I am very glad to have befriended Becky Butler, who has always been ready to listen, to bounce ideas back and forth, to offer a reality check, or to do none of these things and take an evening off together. I also have Becky to thank for the nickname Hank, which quite intentionally sounds like neither of our names. I am grateful for the friendship of fellow linguists Tova Katzir, Serena Crivellaro, Jo Johnson, Johanna Brugman, Cliff Crawford, Julie Balazs, Kyle Grove, Neil Ashton, Seongyeon Ko, Anca Chereches, and the Cornell Linguistic Circle. My last summer in Ithaca, as well as my time as an Italian TA, was made immeasurably more pleasant by the company of Elisabeth Fay and Lorenzo Fabbri; and many evenings were brightened by the culinary genius and hospitality of Michela Baraldi. I also thank my best far-flung friends, Molly Dorfman and Tara Perkins, the delightful travel buddies and companions whom I miss.

Although my family was often far away while I've been in graduate school, they are intimately connected to my experience there. My path towards a Ph.D. goes back two generations, to my geographer parents Hilary Lambert and Bill Renwick; and to my professor grandfathers Ralph Renwick and Bill Lambert, who offered this wisdom: "Just get the Ph.D., and then you can do whatever you want." Throughout my time in graduate school, my mother has been unconditionally supportive and generous, keeping me well-fed through the final stages of dissertation writing and always up-to-

date on life in Ithaca. My father has been my first source for solid advice on academia or life as a whole, and I have greatly enjoyed our travels together over the last few years. I can't mention my family without thanking my brother Oliver Renwick, who shares my love of language and has buoyed me enormously with his understanding and intellectual creativity. Finally, although she won't be reading my dissertation, I would like to thank Aurelia, whose canine companionship has warmed many a winter night and kept me moving when I most needed it.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

xxii

CHAPTER 1: INTRODUCTION

1.1.   Overview

This dissertation investigates the system of phonemic contrasts among Romanian vowels, centering on examples of *marginal contrast*, in which a traditional sharp distinction between allophones and phonemes is insufficient to capture the relationships among sounds. These relationships are considered from historical, phonological and phonetic perspectives through a series of case studies. In several experiments I explore production and perception in Romanian, which presents a prime opportunity for empirically examining the interaction of phonology and morphology and is under-studied with respect to other Romance languages.

This study is motivated by a general interest in how a language's phonological inventory shapes the acoustic realization of its members, and how the language's phonological processes interact with the synchronic phonetics to affect production and perception. In the case of Romanian, we will find that another crucial dimension is the historical one: many facts about the relative frequencies of Romanian phonemes, and their synchronic distribution, can be traced to historical processes and the influences of borrowings throughout the language's history. The dissertation begins with a case study on the development of a marginal phonemic contrast, in the form of a historical question: What is the source of /ɨ/ as a phoneme in Romanian? The historical investigation is paired with a synchronic study of phoneme type frequency, and together they show that despite the presence of minimal pairs, /ɨ/ remains restricted to certain phonological environments and is marginally contrastive in the language. This analysis is extended to other vowels of Romanian, setting the stage for a second set of questions: What are the consequences of marginal contrastiveness for these sounds' phonetics and perception? Where phonological alternations are active, do we find

parallels in the phonetics, and is that variability systematically related to the size and makeup of a language's vowel inventory? The results of these studies have implications for our expectations of how phonological contrast is realized, and for cross-linguistic models of the relationship between vowel inventory size and acoustic vowel space.

The questions taken up in this dissertation highlight the interface of phonetics and phonology, focusing on ways in which phonetic forces drive the phonological system, providing pressure to trigger change over time. However, the inherently interactive relationship between phonetics and phonology allows us to pinpoint areas of systematic and random variability in the acoustics, to understand the variety of forces at play in the Romanian vowel system. Romanian exhibits synchronic morpho-phonological alternations that are unique among Romance languages, providing intra-familial points of comparison. Some alternations are shown to be important for characterizing phonemic contrast in Romanian, while others are found to have parallels in the synchronic phonetics.

This chapter provides background on the topics investigated in the rest of the dissertation. First I provide theoretical motivation for analyses of marginally contrastive phonemic relationships in §1.2. In §1.3 I give an overview of previous linguistic treatises on Romanian, followed in §1.4 by a brief history of Romania and its linguistic situation, including general observations on systematic changes to the Latin vowel inventory that resulted in the Romanian system. The phonemic inventory of Romanian is described in §1.5, and in §1.6 I lay out further typological motivations for studying the language's system of contrasts, based on the relative frequencies of its vowels across the world's languages. Finally, §1.7 outlines the remaining five chapters.

1.2.   Phonological contrast: Categorical or gradient?

Traditionally, a sound is considered to be either *phonemic*, in which case it can be underlyingly specified in a language's lexicon to distinguish one word from another; or a sound is in an *allophonic* relationship with another sound or sounds when its appearance is predictable based on phonological context or other linguistic factors. If two sounds are in an allophonic relationship, the presence of one vs. the other never triggers a change in lexical meaning; in other words, they are not responsible for lexical contrast. This is the case for English [l] and [ɫ], both of which native speakers associate with the phoneme /l/; but the former appears in syllable-initial position, as in *lock* [lɑk], while the latter always falls in syllable-final position, in e.g. *call* [kɑɫ]. Since a sound cannot (typically) be both syllable-initial and syllable-final, these sounds have separate distributions, and cannot form a lexical contrast. Two sounds are considered contrastive when they can appear in the same environment, and the appearance of one vs. the other *does* give rise to a change in lexical meaning; this results in minimal pairs, such as English *heed* [hid] vs. *had* [hæd], in which the substitution of a single sound correlates with different meanings. In many cases, this contrastiveness is reinforced by an abundance of minimal pairs: in English, the contrast between /i/ and /æ/ can be attested also by *bead* [bid] vs. *bad* [bæd]; *beat* [bit] vs. *bat* [bæt]; *read* [rid] vs. *rad* [ræd], *seat* [sit] vs. *sat* [sæt], and many others.

What happens, however, when very few minimal pairs separate two phonemes? This is the case in Romanian, whose vowels /ɨ/ and /ʌ/ contrast in only three widely-cited minimal pairs (see Chapter 2). Additionally we find that where /ɨ/ and /ʌ/ are concerned, it is easy to predict where one phoneme is preferred over the other: /ɨ/ tends to occur in stressed syllables and especially before /n/, while /ʌ/ is typically unstressed. This means that their distributions, while overlapping, are largely

separate. With these two pieces of evidence, we see that the contrast between /ɨ/ and /ʌ/ is not robust. I refer to such contrast as *marginal*.

The idea that phonemes can fall into a relationship of marginal contrastiveness is not a new one; simply put, this captures cases of contrast which are phonemic according to a narrow definition (for example, the presence of at least one minimal pair), but in which the members of the pair fail to freely occur in all the same contexts, and thus are not robustly contrastive. This can be due, for example, to the presence of phonological restrictions or large gaps in the occurrence of each phoneme. When this lack of contrastiveness results in few minimal pairs, as in the case of /ɨ/ vs. /ʌ/, the contrast is described as having a low functional load (Hockett 1966). Phonemic contrasts clearly fall along a continuum, since sounds may exhibit varying degrees of contextual neutralization. One way to characterize marginally contrastive relationships is in subcategories of phonemic contrast; this is eloquently done by Goldsmith (1995) in his introduction to the *Handbook of Phonological Theory*, using the following descriptions:

> (1.1) Contrastive segments: "[I]n every phonetic context in which *x* may be found, *y* may also be found, but in a fashion that produces a word that is grammatically or lexically distinct […]." (Goldsmith 1995:10)
>
> (1.2) Modest asymmetry case: A pair of sounds, *x* and *y*, "are uncontroversially distinct, contrastive elements in the underlying inventory, but […] in at least one context there seems to be a striking asymmetry in the distribution of segments, judging by the relative number of words with the one and words with the other, or by some other criterion." (Goldsmith 1995:11)

(1.3)   Not-yet-integrated semi-contrasts: "[A] language has two sounds, *x* and *y*, which may well be in contrast in some environments, but which in a particular environment show a sharp asymmetry, in that *x* appears in large numbers, while *y* appears in small numbers in words that are recent and transparent borrowings." (Goldsmith 1995:11)

(1.4)   Just barely contrastive sounds: "*x* and *y* are phonetically similar, and in complementary distribution over a wide range of the language, but there is a phonological context in which the two sounds are distinct and may express a contrast. […] Thus while a contrast exists, a stubborn one which will not disappear under scrutiny, the contrast occurs in an extremely small part of the range of contexts in which the sound is found. The contrast is a lexical one, but only just barely." (Goldsmith 1995:11)

(1.5)   Allophones in complementary distribution or free variation: "In the former case, there is no phonetic environment in which both *x* and *y* appear, while in the latter *x* and *y* may occur freely with no lexical or grammatical difference involved." (Goldsmith 1995:10)

Goldsmith's view of phonological contrast is clearly more fully articulated than a binary division between allophones and phonemes; however, we must consider the possibility that contrast is even more gradient than he describes, or that some contrasts result from combinations of factors not captured by Goldsmith's categories. This is the case in Romanian, where the nature of the contrast between /ɨ/ and /ʌ/ depends on the portion of the lexicon we examine: among native words, Goldsmith's category of "just barely contrastive sounds" is appropriate; but when we take into account the influence of borrowings to Romanian, the relationship between /ɨ/ and /ʌ/ seems to be a "not-yet-integrated semi-contrast." When we consider the acoustics,

5

however, we see that the two sounds are distinct, and they seem to be best classified as a "modest asymmetry." Additionally, morphology plays a role in Romanian: we will see that although the diphthongs /e̯a/ and /o̯a/ are separate phonemes, they appear most frequently in a known set of morphological markers, lending a large degree of predictability to their presence. The contrastiveness of /e̯a/ and /o̯a/ is thus different from other cases, because rather than depending on minimal pairs with near-allophones, it depends on the predictability of the vowels' occurrence as a function of morphological context. Goldsmith's continuum considers only '*x* and *y*' pairs of sounds. I ask, therefore, what is the best way to characterize the types of marginal contrast found in Romanian? Is there a category into which these vowels fit, or does the nature of their contrast truly depend on the linguistic dimension (phonetic, phonological, lexical, morphological) under examination?

As pointed out by Scobbie (2005), issues like marginal contrastiveness lie at the heart of the phonetics-phonology interface, but few researchers have turned their attention to considering how it should be treated with respect to theoretical models.[1] Goldsmith's (1995) characterization of the range of possible types of contrastiveness focuses on creating categories, from the perspective of phonological theory, but some recent work has come from the opposite perspective, which assumes that these relationships can be truly gradient. This is the approach taken by Hall (2009), who uses probabilistic calculations based on phoneme co-occurrences in large corpora to determine the degree of contrastiveness between a pair of sounds.[2] While both Hall and Goldsmith offer more continuous characterizations of contrast, Goldsmith

---

[1] Scobbie (2005:3–4) on phonology vs. phonetics more generally: "Though the existence of a border is indisputable in political and physical terms, its location as a precise line on the map (compare phonology) or on the ground (compare phonetics) is somewhat arbitrary and clearly subject to challenge."

[2] Hall (2009) also provides a thorough review of the wide variety of terms and phonological instances used to describe marginal contrast throughout the linguistic literature.

emphasizes pairwise contrasts and the sources of marginal contrastiveness (e.g., borrowings or asymmetrical conditioning). Hall considers ways to quantify contrastiveness without reflecting its source in the phonology, thus focusing completely on the synchronic system.

The premise of Hall's Probabilistic Phonological Relationship Model (PPRM) is that the more predictably a sound is distributed across a corpus, the *less* contrastive it is. This represents a fine-grained attempt to quantify phonological relationships, which furthermore allows the researcher to focus on particular phonological contexts in order to identify places where two segments may be more or less contrastive (for example, in word-final position). While the computational implementation of this method is straightforward, the corresponding perceptual experiments undertaken by Hall fail to show support for the complete gradience predicted by the PPRM. A separate set of perceptual results support a different description of contrastive relations, the Gradient Phonemicity Hypothesis (Ferragne et al. 2011). This model assumes that contrasts within a language are not discrete or absolute, and the authors advocate using production and perception data to test it further.

This dissertation takes a rather different tack, starting from the historical point of view and moving into the synchronic, using not probabilistic modeling but a simpler type frequency-based approach to support case studies of marginal contrast in Romanian. While the analysis is first motivated by a historical account of the evolution of the Romanian vowel system, its scope is not limited to resolving a diachronic question: the corpus used in the type frequency analysis is contemporary, and shows the distributions of Romanian sounds in the language's lexicon. This technique, like that of Hall (2009), provides a non-categorical, gradient view of the co-occurrence relations among segments, while at the same time showing how frequently each segment occurs across the language as a whole and allowing us to gauge the

functional load of individual contrasts. In this way, the work presented here falls at an interesting point along the phonetics-phonology interface: it captures data in a quantitative, gradient fashion, which is characteristic of a phonetic analysis; but the data it uses is phonologically-based rather than acoustic. Pairing this relative-frequency analysis with the acoustic studies in subsequent chapters, I illustrate the degree to which the abstract *system* of phonological contrasts in a language may be driven by factors like phonetic and morphological effects, which are systematic and yet non-categorical.

The case studies here include data on type frequency, phonological conditioning, and morpho-phonological interactions. What emerges from these investigations of relationships among Romanian vowels is the multidimensionality of contrastiveness. The phonemic status of a sound is affected not only by the presence of minimal pairs, but also by the degree to which its presence depends on phonological conditioning, its use within morphological endings, and the frequency of its use. While this thesis does not attempt to quantify precisely the role of each of those factors, I demonstrate the importance of each in order to understand a phonemic inventory as a system of contrasts.

1.3.   Romanian as a focus of study

One goal of this dissertation is to empirically tease apart the relationship between synchronic and diachronic linguistic processes, which have often been conflated in literature on Romanian. Few resources, descriptions, and experimental results reflect on systems within the modern language without focusing primarily on historical sources for linguistic phenomena. However, the prior literature is invaluable in its nearly-exhaustive cataloging of historical processes and developments, from which Chapter 2 of this dissertation draws extensively. Since modern standard

Romanian is based on one of the major dialects of the region, Daco-Romanian, much research has focused on identifying dialectal differences and their historical sources, or on pinpointing the source of etymological puzzles (Rosetti 1956; Vasiliu 1968; Avram 2000). Romanian was isolated, geographically and politically, from other Romance languages during its development, and so many scholars have documented the evidence for its status as a Romance language descended from Latin, tracing lexical items and grammatical factors to their modern outcome by drawing on historical forms (DuNay 1977; Hall 1974; Sala 2005; Mallinson 1988; Alkire & Rosen 2010). Another major contributing factor, described in more detail below, has been the influence of Slavic languages on Romanian (Rosetti 1954; 1986; Dimitrescu 1973; Hall 1974; Mallinson 1988; Petrucci 1999). The contact between Romanian and that family was so extensive that even core lexical items such as verbs like 'love' and 'hate' come from Slavic. Other significant sources of borrowings are Turkish and French, examined by Close (1974), Friesner (2009) and Schulte (2005; 2009), among others.

Some treatises on Romanian are political, either overtly or covertly. Many of the available works on Romanian, particularly those published during the second half of the twentieth century, emerged under the auspices (and in the publishing houses) of the government, which actively supported the idea that the Romanian people were descended from the Dacians, a tribe living in that region prior to the arrival of the Romans. However, it is unclear whether the Dacians actually lived in the area north of the Danube (in present-day Romania), or if their homeland was further to the south; thus there is a debate over the true origins of the Romanian people. Scholars like DuNay (1977) evaluate, from a linguistic point of view, the claims regarding Romania's link with ancient Dacia, by recounting the history of that part of Europe and linking it to specific phonological, lexical and syntactic facts in other languages

and correlating them with geographical distributions. Others (Ivănescu 1980; 2000; Cueşdean 2006) survey the relationship between Romania's social and geographical history, which have been heavily influenced by surrounding populations, to show those factors' effect on the language.

Historical evidence about Romanian is often based on direct lexical comparisons rather than reconstruction; maps are frequently employed to illustrate the distribution of lexical forms throughout the dialectal regions of Romania (Rosetti 1956; Ivănescu 1980; 2000; Vasiliu 1968; Coteanu 1981). Much of our earliest knowledge of Romanian comes from fragments of text, many written in Old Church Slavonic or Cyrillic script, or involving place names, which are compiled in some volumes (Dimitrescu 1973; Rosetti 1954). Others survey corpora, for example to demonstrate the antiquity of Romanian among European languages (Cueşdean 2006), the language's etymological structure (Maneca 1966), or to describe more recent influxes of lexical material, in writing samples dating from the 18th Century (Close 1974). In certain works, the focus falls on literary Romanian (Gheție 1974; Mancaş 1974; Maneca 1966; Rosetti 1971; Țepelea 1973), or on the history of Romanian linguistics and philology (Grecu 1971; Close 1974), which distances the material from the spoken language and descriptions of synchronic phonological phenomena.

Increasingly, linguists are studying the synchronic status of Romanian phonological elements; however, these bodies of work are dwarfed by the historically-based materials. Significant quantitative or synchronically-based phonological works include generative and laboratory phonology approaches (Chițoran 2002a; 2002b; Chițoran & Hualde 2007); but this tradition in fact traces its roots to the major Romanian linguists of the twentieth century, including Alexandru Rosetti and Andrei Avram. Some of their observations on modern Romanian facts are collated in collections of essays (Rosetti 1959; 1973a), which include synchronic treatises on

phonology and phonetics, for example determining the phonological status of various palatalized consonants. Rosetti (1959) provides perhaps the earliest experimental explorations of the Romanian diphthongs, including rudimentary phonetic data. These glide-vowel sequences, which are typologically rare due to their unitary phonological structure (Chiţoran 2002c) have also been considered from an Articulatory Phonology perspective (Marin 2005; Marin 2007; Marin & Goldstein 2012), to explore the timing of gestures within them. The close relationship between phonological alternation and morphological marking (Chiţoran 2002c) has figured in recent models of their interaction and its implications for the lexicon (Steriade 2008). An English-language sketch by Augerot (1974) collocates and sifts through many historical accounts of Romanian phonological processes, to provide useful generalizations overlooked by previous scholars, while weighing in on issues such as the status of /ʌ/ in the language and sources for /ɨ/.

In giving primacy to a historical point of view, earlier researchers have captured something quite noteworthy about Romanian – namely that the history of the language, and indeed of the country in which it is spoken, is clearly reflected in the language itself, particularly in its lexicon. In the Romanian lexicon, we find a core of native Latin roots dating to the Roman empire, with a few very old words of Dacian (pre-Roman) origin; on top of that are many Slavic borrowings, some of which have penetrated to the core vocabulary of Romanian, such as *a iubi* 'to love' or *a omorî* 'to kill'. Turkish invasions brought new waves of loanwords with particular semantic connotations, related to military and government activities; borrowings from French and other Romance languages are often literary or cultured terms (Friesner 2009). Recently, technological terminology has been imported from English, where it is minimally adapted for use in contemporary Romanian. What emerges in the following chapters is how these social and linguistic interactions affected not just the Romanian

11

lexicon, but also its phonology, helping to shape the phonemic inventory and synchronic phonological patterns. While the idea that borrowings affected Romanian phonology is not a new one (Petrovici 1957; Rosetti 1958; 1973b; Vasiliu 1968; Hall 1974; Sala 1976; Ivănescu 1980; Petrucci 1999; Schulte 2009), I will demonstrate that these loans interacted with native phonological processes to produce a complex inventory in which the line between allophone and phoneme is blurred. I show that by examining the synchronic lexicon, rather than considering etymological sources alone, we can clearly see the effects of these historical processes.

1.4.   Romania and Romanian: A brief historical sketch

Linguistically, Romanian belongs to the Romance family, with strong lexical, grammatical and phonological links to Italian, French, Spanish, Portuguese, and other Romance languages. Geographically, however, the area in which Romanian is spoken is not contiguous with the western European nations in which those languages are spoken. Modern-day Romania is bordered by the Black Sea, Moldova (also largely Romanian-speaking), Ukraine, Hungary, Serbia and Bulgaria. A map of modern Romania appears in Figure 1.1.

Figure 1.1.   **Map of Romania (University of Texas at Austin 2011)**

1.4.1. History and its linguistic consequences

Romanian's ties to its language family began with Roman annexation of
territory previously controlled by the Dacian tribes, who occupied an area north of the
Danube River; a few Romanian words are still traced to the Dacian language. Roman
rule lasted only from 106 to 271 C. E. Following the Romans' retreat, Romania was
invaded and administrated by waves of different migratory populations, and during
this time the developing Romanian language first encountered the Slavic language
family, beginning in the 7th Century. In the Middle Ages, Romania (subdivided into
Wallachia, in what is now southern-central Romania; Transylvania, to the northwest;
and Moldavia, to the northeast) underwent periods of rule by, and conflict with, the
Ottoman Empire; during this time, the language experienced extensive contact with
Turkish. Transylvania, which borders modern day Hungary, and parts of Wallachia
were ruled by the Austro-Hungarian Empire in the 18th and 19th Centuries, before

13

Wallachia united with Moldavia in 1859 (followed by Transylvania only in 1920) under a monarchy. Many Hungarians still live in Transylvania, and some schools are bilingual.

During the 18th Century, Romanian intellectuals became aware of their language's links to Latin, and began efforts to Romanize it, by changing the alphabet (Romanian was first written in the 16th Century, using Slavonic scripts) and by importing Romance *cultismos*, especially from French. Romanian territory reached its greatest extent between World Wars I and II, but was reduced following the separation of the Republic of Moldova. Monarchic rule ended in 1947, during the Soviet occupation, and from 1965 until 1989 the country was led by Nicolae Ceauşescu's Communist regime. Presently, Romania is a democracy, and joined the European Union on January 1, 2007. At least 2 million Romanians have emigrated, resulting in large Romanian-speaking populations in the United States, Canada, Italy, and other European countries.

As of the 2002 census, there were 19,700,000 speakers of Romanian in Romania, and a total of 23,351,080 throughout the world (Ethnologue 2011). According to some sources Romanian has great lexical similarity with other members of the Romance family, ranging from 71% (with Spanish) to 75% with French and 77% with Italian (Ethnologue 2011); however, it is clear that much of this similarity arises not from native Latin-based vocabulary but from modern Romance borrowings, particularly from French. The language contains a large number of borrowed words. While there is much variation in the number of borrowings across semantic fields, an average of 42% of words (with a median of 45%) are borrowed across the lexicon (Schulte 2009), and within the literary language (where borrowings, particularly from other Romance languages, are very common), the core, native vocabulary has been claimed to account for only 35% of words (Maneca 1966). In pseudo-literary text

samples such as newspapers, Romance-based lexical items (including native and borrowed words) account for as much as 85% of the vocabulary (Mallinson 1988:417). While Romanian is clearly a Romance language, as measured by lexical content and morphosyntactic similarities, loanwords are not restricted to non-core lexical categories; even core words such as 'love' – both the verb and noun – are borrowed: *a iubi* 'to love' and *dragostea* 'love' are of Slavic origin. Chiţoran (2002b) outlines the structure of the Romanian vocabulary, which is linked to the language's diachronic development and the history of the area in which it is spoken. Within the core vocabulary, which represents the native phonology, are words from Latin and Slavic, Hungarian, and some Albanian and Turkish loans; the foreign vocabulary of partly-assimilated items includes French, Italian, Greek, Turkish, and some German loans; and finally, recent loans from English constitute a group of unassimilated lexical items (Chiţoran 2002b:31–32).

In addition to Schulte's (2009) discussion of loanwords in Romanian, Friesner (2009) evaluates the role of Turkish and French among Romanian loanwords; and Petrucci (1999) details the effects of Slavic influence on Romanian. The statistics of the Romanian lexicon, as well as Romania's history of sociocultural interaction with many populations and ethnic groups, indicate that language contact figures largely in the language's history. As the authors cited above show, and as this dissertation reiterates particularly in Chapter 3, these influxes of words with structures different from the Latinate core of Romanian have had strong influences on the language's phonology.

1.4.2. Vowels: From Latin to Romanian

Latin had ten vowel phonemes, all contrasting in length (long vs. short): /Ī Ĭ Ē Ĕ Ā Ă Ō Ŏ Ū Ŭ/. Generally, across the Romance languages, the evolution from

Latin to the modern languages involved two processes: the universal loss of quantity (length) and various language-dependent height-related mergers (Alkire & Rosen 2010). In late Latin, prior to its split into the Romance languages, a pair of mergers occurred among mid vowels: /ĭ/ and /ē/ merged to /e/ in the front, and /ŭ/ and /ō/ merged to /o/ in the back of the vowel system. This produced a seven-vowel system: /i e ɛ a ɔ o u/. Later, diphthongization occurred in Spanish and Italian, to affect low mid vowels in particular and produce /uɔ/ and /jɛ/ in Italian, and /uɛ/ and /jɛ/ in Spanish; French stressed vowels underwent a series of changes. In Romanian, late Latin /i/ produced /i/; /e/ (from the merger of /ĭ/ and /ē/) emerged as /e/; /ĕ/ diphthongized to /jɛ/ in both open and closed syllables; /a/ remained /a/, and /o/ merged with /ɔ/ to give /o/; and late Latin /u/ remains /u/ in Romanian. Other post-Latin characteristics of Romanian are the emergence of its diphthongs (see Chapter 4), the development of the central vowels /ʌ/ and /ɨ/ (Chapter 2) and the presence of extensive pre-nasal raising of stressed vowels (§2.1). For a more extensive overview of the phonological changes that took place between Latin and Romanian, see Alkire and Rosen (2010:chap. 10).

1.5.   Romanian phonemes

The phoneme inventory of Romanian has been the subject of much debate by scholars of the language. Regarding the vowel inventory, there has been disagreement as to whether diphthongs should be generated by rules combining glides and monophthongs (Avram 1958; 1991; Agard 1958; Vasiliu 1990), or whether they are instead underlying and thus listed among the phonemes (Evdoshenco 1961; Havránek 1933; Graur & Rosetti 1938). Additionally, authors disagree on the necessary number of vowel heights and features for Romanian. Trubetzkoy (1939) argues that the diphthongs are lower than /e/ and /o/ but higher than /a/, giving four degrees of height;

others typically include three heights. For the purposes of this dissertation, I adopt the square phonemic inventory for vowels also used by Chiţoran (2002c:208) and Graur and Rosetti (1938); this includes the diphthongs, and is shown in (1.6).

(1.6)   Romanian vowel inventory

	front	central	back
high	i	ɨ	u
mid	e	ʌ	o
low	ea̯	a	o̯a

Where consonants are concerned, there is less variability in scholars' inventories, although Petrovici (1956) argues that a series of palatalized consonants exist in parallel to plain ones. I adopt the consonant inventory shown in Chiţoran (2002b:10), in (1.7).

(1.7)   Romanian consonant inventory

	labial	dental	palatal	velar	glottal
stops[3]	p, b	t, d	tʃ, dʒ	k, g	
		ts			
fricatives	f, v		ʃ, ʒ		h
nasals	m	n			
approximants		l			
		r			

---

[3] Steriade (2008) additionally includes the palatal stops [c, ɟ] in her inventory of Romanian segmental contrasts; however, it is not clear if these are argued to be phonemic, as the palatal versions appear before [e, i] only.

This dissertation necessarily takes a position on the transcription conventions for each Romanian phoneme and a remark must be made regarding the mid central phonemic vowel, which I transcribe /ʌ/. The standard transcription of this vowel is /ə/ (schwa); however, this usage may suggest that the vowel in question is a reduced one, which perhaps participates in phonological neutralizations in prosodically weak positions. While the mid central vowel historically developed in unstressed syllables and was likely a reduced vowel, it functions synchronically as a full vowel and should be distinguished from reduced vowels. In fact, one of the findings of Chapter 4 is that Romanian /ʌ/ occupies its own acoustic space, and does not have the degree of variability of formant values that we might expect from a targetless reduced vowel. Durationally, it patterns with other vowels of its height class and thus is not reduced in that dimension. For these reasons I treat Romanian's mid central vowel unambiguously as a full vowel, even in unstressed position (where synchronically it is contrastive as a morpheme). Precedent for this transcription comes from Steriade (2008).

1.6. Romanian: Typological considerations

Romanian makes an interesting focus of study for several reasons. First, among the major Romance languages, it is less studied than its western counterparts, such as Italian, French and Spanish, to the degree that new data on Romanian can inform not only linguistic theory, but also our descriptive knowledge of Romance typological characteristics. Thus for scholars of Romance languages, new in-depth studies of Romanian showcase the lesser-known eastern branch of the family, helping represent the full breadth of typological possibilities that have evolved from their common ancestor, Latin.

When we consider Romanian against the larger backdrop of linguistic theory and typology, it is notable for several characteristics related to its phonology, which can be viewed not only from within the synchronic system, but as a result of the language's historic development, and also in terms of its interactions with morphology. Romanian has two phonemic central vowels, /ɨ/ and /ʌ/, a contrast which is unique among Romance languages. These two historically allophonic vowels are phonologically marginally contrastive, meaning that they appear in nearly-complementary distribution and are separated by only a handful of minimal pairs, yet they are separate phonemes. In addition to its two central vowels, Romanian has two diphthongs /e̯a/ and /o̯a/, which are phonologically unary (Chiṭoran 2002c) but have two phonetic targets (see Chapter 4). Like the central vowels, these diphthongs originated under predictable phonological conditions, but are now phonemic.

From a typological point of view, the vowel system of Romanian is unusual in its use of cross-linguistically infrequent central vowels, but among seven-vowel systems the presence of /ɨ/ and /ʌ/ is not unusual (Liljencrants & Lindblom 1972; Lindblom 1986). According to the UCLA Phonological Segment Inventory Database (UPSID; Maddieson 1984; Maddieson & Precoda 1990) as analyzed using the website interface maintained by Henning Reetz,[4] neither /ɨ/ nor /ʌ/ (or /ə/, as the vowel is transcribed in UPSID's entry on Romanian) appears on the list of the ten most common vowel categories among the world's languages. The most common vowels, all appearing in more than 30% of inventories, in descending order of frequency as transcribed in UPSID are: /i/ /a/ /u/ /"o"/[5] /"e"/ /ɛ/ /o/ /e/ /ɔ/ (Maddieson 1984:125). With regard to the size of the vowel inventory, whether we include only the seven monophthongs in Romanian, or add the diphthongs to reach nine vowels, we find that

---

[4] http://web.phonetik.uni-frankfurt.de/UPSID.html
[5] Vowels in double quotes are mid vowels whose precise height quality – i.e. "higher mid" vs. "lower mid" – is not clear from available phonological transcriptions (Maddieson 1984:123)

the language does not have an unusually small or large inventory. In the UPSID database (Maddieson 1984, Table 8.3), 10.7% of languages have seven vowels, and 8.8% have nine. If we include the diphthongs, Romanian becomes more interesting typologically, because as shown by Chițoran (2002c), its diphthongs are phonologically unary, not composed of two phonological units. Languages with this property are rare among the world's languages (Maddieson 1984), and among those that do have unary diphthongs, neither /e̯a/ nor /o̯a/ is common.

1.7. Structure of the Dissertation

Following this introductory chapter, the next two chapters consider, respectively, a historically-based phonological question and its consequences for the synchronic phonological system of Romanian. Chapter 2, "On the origins of /ɨ/ in Romanian," focuses on the historical roots of /ɨ/ in Romanian, and demonstrates that a combination of native phonological processes and subsequent borrowings, particularly from Slavic and Turkish, joined forces to shape the vowel's synchronic distribution. The chapter also presents evidence that /ɨ/ truly is phonemic synchronically, and describes the contexts (morphological endings or word classes) in which it is likely to be found.

Chapter 3, "Case studies in Romanian type frequency," is a quantitative counterpart to Chapter 2. It focuses on rates of relative type frequency among Romanian phonemes, particularly the vowels, and argues that /ɨ/, /e̯a/ and /o̯a/ are all marginally-contrastive phonemes in the language, meaning they do not fit into a binary distinction between phonemes and allophones. These three vowels all have very low type frequency, and their distribution can almost be predicted, but a few minimal pairs and some overlap in environments in each case require that they be treated as phonemes. Additionally, the synchronic distribution of each vowel is

crucially tied to the influence of loanwords (this is demonstrated for /ɨ/ in Chapter 2, and for the diphthongs in Chapter 3). While /ɨ/ now contrasts with its former allophone /ʌ/, it in fact retains its historical, phonologically-conditioned distribution, such that the two phones are in nearly-complementary distribution. The diphthongs' presence, on the other hand, is heavily conditioned by morphology. These vowels are synchronically used in many morphological endings, and their distribution can be captured largely by enumerating the morphological environments in which they appear. This comparison of three vowels demonstrates that marginal contrastiveness is a multidimensional property dependent not only on the presence of minimal pairs, but also on phonological conditioning, morphologized use, and relative frequency.

The fourth and fifth chapters focus on the acoustics of the Romanian vowel system, with an additional comparison to Italian. Chapter 4 presents the results of a phonetic investigation of Romanian phonemic vowels, from data collected at Cornell University and in Cluj-Napoca, Romania. These data, from 17 native speakers, contribute greatly to our knowledge of the acoustics of Romanian. The chapter first describes the experimental methodology used in phonetic experiments throughout the dissertation, and my field work experience. It presents the results of a study of the acoustics of Romanian vowels, designed to document the positioning of monophthongs and diphthongs in the Romanian vowel space. The chapter demonstrates that /ɨ/ and /ʌ/ have separate acoustic realizations, and that the diphthongs have two acoustic targets, one mid vowel and one low vowel target. It also presents the durational characteristics of Romanian vowels, taking into account factors including stress, syllable structure, word position, and vowel height. Finally, the chapter describes two pilot perceptual experiments, one conducted in Romania and one at Cornell, investigating the relationship between the marginal contrastiveness of vowels and their perception. Fuller details are included in Appendix C.

Chapter 4 examines the vowels of Romanian in order to capture their most basic characteristics, which in turn facilitates a phonologically-motivated examination of vowels' characteristics as a function of the surrounding context. Chapter 5 presents the results of a phonetic experiment comparing coarticulation in Romanian (9 speakers) and Italian (8 speakers). The experiment builds on a pilot study finding that Romanian stressed vowels, which also undergo phonological metaphony, are subject to considerable anticipatory coarticulation. Standard Italian does not have this phonological property, and thus serves as an excellent comparison in a controlled nonce-word study of coarticulation. The results demonstrate that rates of coarticulation are not symmetrical across anticipatory and carryover contexts, and that the magnitude of coarticulation varies across target vowels. We see larger coarticulatory effects in Romanian than Italian, and Romanian shows an important asymmetry: anticipatory vowel-to-vowel coarticulation exceeds carryover vowel-to-vowel coarticulation, paralleling the right-to-left directionality of metaphony. Patterns of consonant-vowel coarticulation in Romanian also parallel phonological processes unique to that language. Finally, context-dependent differences in phonetic variability between Romanian and Italian have implications for cross-linguistic models of the relationship between vowel inventory size and acoustic vowel space.

The dissertation concludes with Chapter 6, which synthesizes the results of each study and experiment, and lays out directions for future research, including two perceptual experiments. This chapter draws parallels between the discussions of marginal contrast and the effects of coarticulation in Romanian as case studies illustrating the systematic but non-categorical mapping between phonology and phonetics. These studies are additionally linked by an overarching theme: the role of morphophonological processes in shaping the Romanian inventory and its synchronic phonetics. Finally, I propose a model of the forces that combine and interact to

determine phonemic robustness among the sounds in a language. Taken together, these results have implications for models of the phonetics-phonology interface. Several appendices augment the body of the dissertation, adding details regarding loanwords relevant for the historical chapters, as well as additional phonetic results and those of the pilot perception experiments.

CHAPTER 2: ON THE ORIGINS OF /ɨ/ IN ROMANIAN

2.1. Introduction

How does a new sound become phonemic in a language? What can we know about the roles of native phonology and loanwords in the development of a new phoneme, and how extensively can this newly-contrastive element expand into the lexicon? Can it expand freely or are there restrictions on where it will appear? This chapter explores these questions through a case study of Romanian's high central vowel /ɨ/, from its allophonic origins to its synchronic phonemic status. The origins of /ɨ/ are shown to be strongly linked to its distribution within the synchronic vowel system, which is the central focus of this dissertation. While it participates in minimal pairs and is thus demonstrably phonemic, /ɨ/ exhibits a strong tendency to appear in a limited set of segmental contexts, notably in stressed pre-nasal position and in the vicinity of /r/. Since this distribution is nearly complementary with that of mid central /ʌ/, as introduced in Chapter 1, these vowels are in a relationship of marginal contrastiveness, the roots of which we will see in this chapter. Furthermore, as we will see in detail in Chapter 3, /ɨ/ is relatively rare within the Romanian lexicon; it appears with much lower frequency than other vowel phonemes and is rarely used in recent additions to the lexicon.

Given these facts, which additionally motivate the phonetic study in Chapter 4, a question emerges: What are the properties of /ɨ/ that have given rise to these restrictions on its distribution? The present chapter investigates that question from a historical point of view, and together with Chapter 3 provides convincing evidence that the presence of /ɨ/ as a phoneme in Romanian is the result of a convergence of historical processes which not only can be enumerated in detail, but are also virtually coextensive with the vowel's distribution in the modern lexicon.

While this chapter is philological in nature, it is supported by a systematic quantitative methodology. My goal was to survey the full range of occurrences of /ɨ/ in Romanian, in order to compare their phonological and etymological characteristics and to reflect on patterns therein. Thus while references are made to other authors' observations on the history of /ɨ/, the data showcased here are the result of my own compilation of the occurrences of that vowel across the Romanian lexicon. This was accomplished through dictionary searches (Cioranescu 2002; DEX 2011; Miroiu 1996) for words containing /ɨ/ which were categorized according to preceding and following segments, stress conditions and language of origin, in case they were loanwords. This wide-scope approach offers new insights that do not emerge when one considers data from a more limited set of etymological sources.

The origins of /ɨ/ as a phoneme of Romanian have been debated by a variety of the language's scholars: Did the vowel develop within Romanian, or was it introduced through loanwords and later phonologized? Several authorities on the history of Romanian describe /ɨ/ as a phoneme that split from /ʌ/, which is itself absent from the Popular Latin vowel system (Vasiliu 1968; Coteanu 1981; Rosetti 1986). Others argue that it was borrowed from its Proto-Slavic equivalent, *y or /ɨ/ (Petrovici 1957; Hall 1974; Mallinson 1988). Petrucci (1999) claims that /ɨ/ could not have been introduced through loanwords, for example due to a lack of direct correspondences between loanword vowels and Romanian /ɨ/. While I agree that the development of /ʌ/ in Romanian was a crucial step in creating the modern-day vowel system, I argue that a combination of forces within early Romanian phonology, together with loanwords containing phonemes and clusters that were non-native to Romanian, conspired to shape the modern distribution of /ɨ/ across the Romanian lexicon.

This chapter's philological questions are rendered complex by several factors. Although Roman rule ended in 271 A.D. in what is now Romania, the first extant

document in the Romanian language was not written until the 16th century. During the intervening period, Romanian speakers had extensive contact with speakers of many other languages; thus multiple factors could have affected the language's phonemic inventory over the course of this 1200 year span. Here, I examine phonological patterns in words with /ɨ/, including native words, Old Slavic loanwords, and those that came through Bulgarian, Hungarian, Serbian, Turkish, and other less obvious sources.

To set the stage for a phonological analysis of the distribution of /ɨ/, I discuss the Romanian vowel system, with the Popular Latin vowel system as a starting point. Next, I summarize the sources for /ʌ/, which was in an allophonic relationship with /ɨ/ for much of the history of Romanian. I then lay out the environments in which Latin vowels emerged in Romanian as /ɨ/: these correspondences developed early, beginning with a change from /a/ to /ʌ/ between the 5th and 7th centuries (Ivănescu 1980). The change from /ʌ/ to /ɨ/ was largely motivated by pre-nasal raising, a common phenomenon in Romanian. However, the split of /ʌ/ and /ɨ/ into separate phonemes occurred as recently as the 16th century (Vasiliu 1968; Sala 1976; Coteanu 1981; Rosetti 1986). I first survey the data from native Romanian words, then loanwords from other languages and the conditions under which they lead to /ɨ/ in Romanian. Taking Rosetti (1958) as a point of departure, I show additional conditions under which borrowings have given rise to /ɨ/ in Romanian.

2.1.1. Vowels: from Latin to Romanian

In (2.1) we see the phonemic vowels of Latin, from which the modern Romance vowel systems arose. In Latin, quantity in addition to quality was a distinctive feature. The shading in (2.1) shows which vowels merged on the way to

Romanian. The vowel chart of Romanian appears in (2.2); with respect to (2.1), we see the collapse of /ĭ/ and /ē/ into /e/; of /ō/ and /ŏ/ into /o/, and /ū/ and /ŭ/ into /u/.

(2.1)　　　　　Latin Stressed Vowels

/ī/				/ū/
	/ĭ/			/ŭ/
	/ē/		/ō/	
		/ĕ/	/ŏ/	
		/a/		
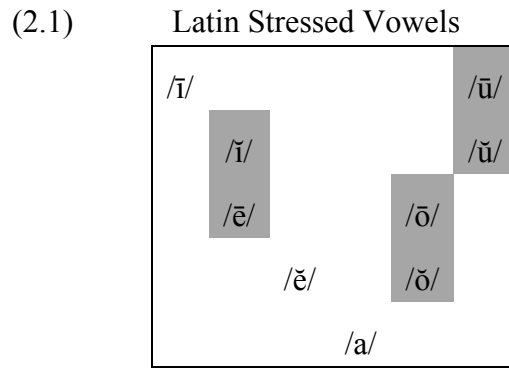
(2.2)　　　　Romanian Vowels

Phonemic Vowel Chart

/i/	/ɨ/	/u/
/e/	/ʌ/	/o/
	/a/	

Orthography

i	â / î	u
e	ă	o
	a	

High central /ɨ/ is closely related to Romanian /ʌ/, so I also briefly examine the history of that vowel. While other Romance languages such as French, Catalan and Portuguese make use of /ʌ/ (or /ə/), no other Romance language has /ɨ/, and no other Romance language uses these two central vowels frequently under stressed conditions, as is the case in Romanian. Here I consider /ɨ/ and its emergence within the vowel system as a whole: there are several possible ways for it to have entered the language. Did /ɨ/ emerge from a split, in which a single native vowel separated into two phonemes? Or, did it come from a variety of vowel sources under a definable set of phonological conditions? I argue that both processes occurred. While reconstructions of Common Romanian and the Romanian dialects indicate that many instances of /ɨ/

came from a phoneme with allophones [ʌ] and [ɨ], suggesting a split, there is also evidence that borrowings through contact with other languages pushed /ɨ/ towards phonemic status in Romanian. In the case of borrowings, however, it is not always possible to define phonological conditions that resulted in /ɨ/.

2.1.2. A brief history of Romanian /ʌ/

The phoneme /ʌ/, written < ă >, is shared among all the dialects of Romanian, including Daco-Romanian (which developed into modern Romanian), Istro-Romanian, Aromanian and Megleno-Romanian. This indicates that /ʌ/ is a shared innovation dating to the Common Romanian period. Its development can be described generally as a split from the Popular Latin vowel /a/, at first in unstressed syllables. The Common Romanian period extended from roughly the 7th or 8th Century A.D. until the 10th Century A.D. (Rosetti 1973b; Rosetti 1986), after which the influence of Slavic languages intensified. The Common Romanian vowel system had six phonemes, seen in (2.3).

(2.3)   Common Romanian Vowels

i		u
e	ʌ	o
	a	

In Common Romanian, /ɨ/ had not yet emerged as a phoneme, and the difference between the Common Romanian vowels and the Popular Latin five-vowel system is the presence of /ʌ/. The development of /ʌ/ was an innovation not only of Common Romanian, but also of the Balkan/South Slavic languages with which Romanian had contact (Rosetti 1973b).

As mentioned above, the main source for /ʌ/ was Latin unstressed /a/, but other vowels could produce /ʌ/, as illustrated by Rosetti (1986), Coteanu (1981) and Vasiliu (1968). However, there are different visions for the phonemic development of /ʌ/ as a phoneme. Coteanu (1981:78) suggests that /ʌ/ became its own phoneme – not just an unstressed allophone – after the 7th Century, when /a/ became the definite article of many feminine singular nouns, creating minimal pairs like *casă* /kasʌ/ 'house' ~ *casa* /kasa/ 'the house.' This opinion is shared by Vasiliu (1968); both authors additionally argue that the change of [a] to [ʌ] before a nasal allowed [ʌ] to "expand its domain" and become a distinct vowel, particularly because this raising occurred in stressed syllables. In contrast, Rosetti (1973b:79) claims that Common Romanian had only five vowels, in which [ʌ] was a variant of /a/; but he includes < ă > in his vowel chart of Common Romanian, making it unclear whether he takes [ʌ] to be phonemic.

I agree that the contrast between indefinite and definite feminine forms is a likely force for pushing [ʌ] to phoneme status, since it is a process that productively creates minimal pairs between [ʌ] and the vowel from which it split. Regarding the claim by Rosetti (1973b), I agree with Petrucci (1999:64) that since all the Romanian dialects show some version of a central vowel, it is very likely that /ʌ/ was a phoneme during the Common Romanian period.

As part of the Romanian phonological system, /ʌ/ was subjected to the effects of metaphony, a type of vowel harmony in which a vowel's quality is conditioned by that of a vowel in a subsequent syllable; for example, consider the pair [ˈkarte], [ˈkʌrtsʲ] 'book, books', in which the presence of a high-front gesture (underlyingly /i/) in the plural form triggers raising of the preceding stressed vowel. Vowel alternation processes are very common in Romanian, and are generally governed by front vowels, which can trigger monophthongization of diphthongs assumed to be underlying. Other non-metaphonic alternations also occur: for example, in some forms [ʌ] alternates

with [e]. The central vowel appears following a labial consonant as long as a front vowel does *not* follow in the next syllable; in that case, /e/ surfaces instead (Rosetti 1986:332). An example is *măr* [mʌr] 'apple' vs. *mere* [mere] 'apples' (for further discussion of the Labial Effect see Chapter 5).

It is difficult to describe the history of /ʌ/ in Romanian without bringing /ɨ/ into the picture, and vice versa. It is unclear whether [ʌ] developed directly out of unstressed /a/ and other phonological conditions, and only later [ɨ] emerged; or whether [ʌ] and [ɨ] existed side-by-side in the phoneme /ʌ/, which split from /a/. One analysis based on phonological rules comes from Petrucci (1999), whose description of Romanian /ɨ/ is prefaced by a pair of rules that describe the development of /ʌ/, seen as an intermediate stage for words now containing /ɨ/:

(2.4)   a) Raising of non-initial, unstressed */a/:   */a/ > */ʌ/ / C ___

$$\text{[-stress]}$$

b) Raising of /a/ before a nasal: /a/ > */ʌ/ / ___ $\begin{cases} n(C)(V) \\ mC \end{cases}$

$$\text{[+stress]}$$

(adapted from Petrucci 1999:64)

Having examined two conditions under which /a/ changes its quality, we have set the stage for our next topic, the emergence of /ɨ/ in Romanian.

2.2.   Historical sources for /ɨ/: Latin

The sources for /ɨ/ include native Romanian words, from Latin. The changes that took place in these words represent, for the most part, a stage of Romanian

development during which /ɨ/ was not a phoneme. I propose that [ɨ] began as an allophone of /ʌ/ or even /a/ in Romanian native words, in stressed position before a nasal consonant. Later changes introduced further environments for [ɨ], and ultimately an influx of borrowings from Slavic languages (§2.3 and §2.4) encouraged [ɨ] in environments far removed from stressed pre-nasal position. In this section, however, I concentrate on generalizations based on native vocabulary. Several of these are described by Petrucci (1999), who seeks to demonstrate that /ɨ/ developed not as a result of the influence of Slavic loanwords, but as a series of changes in the native phonology of Romanian. Although his view is problematic (see §2.3), Petrucci's (1999) rules are a useful starting point for a discussion of how Romanian arrives at /ɨ/ in native words.

2.2.1. Latin /a/ → Romanian /ɨ/

The most obvious source for /ɨ/ in native words is pre-nasal stressed Latin /a/, which raises before /n/, and before /mC/, to become /ɨ/:

(2.5)   Pre-nasal raising of /a/

Latin	Romanian[6]		
campus	câmp	/kɨmp/	'camp, field'
lana	lână	/lɨnʌ/	'wool'
mane	mâine	/mɨine/[7]	'tomorrow'

---

[6] In Romanian, /ɨ/ has two different spellings. The following conventions currently hold: /ɨ/ is spelled < â > word-internally; but at word edges and optionally in proper names, the spelling is < î >. Additionally, the vowel /ʌ/ is written < ă >.

[7] A dialectal variant led to the diphthongization of /*ɨ/ in this particular word.

31

Pre-nasal raising, as exemplified here in the change of /a/ to /ɨ/, is conspicuous in Romanian. In addition to central vowels, front and back vowels also raise before nasals:

(2.6)   Pre-nasal raising in native Romanian words

Latin	Romanian		
bene	bine	/bine/	'well' (adv.)
dente	dinte	/dinte/	'tooth'
venit	vine	/vine/	'comes'
bonu	bun	/bun/	'good'
nomen	nume	/nume/	'name'
fronte	frunte	/frunte/	'forehead'

In the case of /a/ > /ɨ/, it is generally assumed (Rosetti 1973a) that /a/ did not directly become /ɨ/, but instead passed through the intermediate stage of /ʌ/, giving reconstructed *câmp /*kʌmp/, *lână /*lʌnʌ/, for example. It is worth recalling that /ɨ/ is found in *stressed* syllables, while the origins of Romanian /ʌ/ lie in unstressed syllables. This pattern of /a/ → /ɨ/ therefore suggests two possibilities: either that the domain of /ʌ/ spread to stressed syllables and was no longer restricted to unstressed syllables; or that once non-low central vowels began to be produced in Romanian, the tendency for pre-nasal raising was able to spread to /aN/ sequences, in addition to /eN/ and /oN/ sequences. According to the rule proposed by Petrucci (2.4), pre-nasal raising of central vowels began with /a/ > /ʌ/, assuming /ʌ/ was no longer restricted to unstressed syllables.

Several paths lead to Romanian /ɨ/ from Latin vowels. First and foremost, as mentioned, /ɨ/ comes from Latin stressed /a/ before /n/ or /mC/. This is described by the following rule:

$$(2.7) \qquad */\Lambda/ \rightarrow /ɨ/ \;/ \;\underline{\quad} \begin{cases} n(C)(V) \\ mC \end{cases}$$

$$[+stress]$$

(adapted from (Petrucci 1999:65)

Note that here, an intermediate stage of vowel development is assumed between Latin and what is reflected by the synchronic form. Since the intermediate forms are not attested, I have added an asterisk to show that /ʌ/ is reconstructed only; additional examples appear in (2.8) and (2.9).

(2.8)　　/an/ → /ɨn/:

Latin	Romanian		
plangere	plânge	/plɨndʒe/	'complain'
manducat	mănâncă	/mʌnɨnkʌ/	'eats'
manet	mâne	/mɨne/	'remains' (vb)
lana	lână	/lɨnʌ/	'wool'
romanu	român	/romɨn/	'Romanian'
angelu	înger	/ɨndʒer/	'angel'
quando	când	/kɨnd/	'when'

(2.9)   /amC/ → /ɨmC/

Latin   Romanian

*sa(m)batu   sâmbătă   /sɨmbʌtʌ/   'Saturday'

strambu   strâmb   /strɨmb/   'twisted'

campu   câmp   /kɨmp/   'field'

*campia   câmpie   /kɨmpie/   'plain, field'

gamphae   gâmfã   /gɨmfʌ/   'gizzard'

*aggambat   agâmbă   /agɨmbʌ/   'follows'

In some words, the nasal that triggered the raising has since deleted. Petrucci (1999) does not recognize these forms as pre-nasal raising, assuming simply that /ʌ/ was in place and raised to /ɨ/. Yet there is clear evidence of the original conditioning environment, as in (2.10).

(2.10)   /an/ → /ɨ/

Latin   Romanian

aranea   râie   /rɨje/   'mange'

granu   grâu   /grɨw/   'wheat'

quantu   cât   /kɨt/   'how much?'

brandeu   brâu   /brɨw/   'belt, girdle'

2.2.2. Latin non-low vowels → Romanian /ɨ/

While /a/ is the clearest source for /ɨ/ in native Romanian words, other vowels also give /ɨ/. Stressed or pre-tonic /e/ became /ɨ/ before a nasal, thus backing as well as raising.

(2.11) Backing of Latin vowels to /ɨ/

Latin	Romanian		
commendat	comândă	/komɨndʌ/	'sacrifices' (vb)
*dismentare	desmânta	/desmɨnˈta/	'change someone's mind'
pavimentu	pământ	/pʌmɨnt/	'earth, land'
templa	tâmplă	/tɨmplʌ/	'temple'
ventu	vânt	/vɨnt/	'wind'

To describe the conditions under which Latin /e/ emerges as /ɨ/ in modern Romanian, Vasiliu (1968:132) offers two phonological rules, seen in (2.12), embodying the assumption that a change of /e/ to /ʌ/ had to occur prior to prenasal raising in order to produce /ɨ/.

(2.12) a) [e] > [ʌ] / ___ $\begin{cases} \text{V } [-\text{front}] \\ \# \end{cases}$

   b) [ʌ] > [ɨ] / ___ $\begin{cases} \text{n(C)(V)} \\ \text{mC(V)} \end{cases}$

When we consider words like Latin *teneru* 'young, tender' or *templu* 'temple,' we see that as Vasiliu (1968) describes, if rule (b) were ordered before rule (a), we would expect /tʌnʌr/ and /tʌmplʌ/ in Romanian. However, we find /tɨnʌr/ and /tɨmplʌ/, indicating the ordering (a) < (b). Additionally, /i/ before a nasal (2.13) gives Romanian /ɨ/, though not reliably.

(2.13)   Pre-nasal /i/ → /ɨ/

Latin	Romanian		
imbracat	îmbracă	/ɨmbrakʌ/	'gets dressed'
luminare	lumânare	/lumɨnare/	'candle'
sinus	sân	/sɨn/	'bosom, breast'
scintilla	scânteie	/skɨnteje/	'sparkle'
zinzala	ţânţar	/tsɨntsar/	'mosquito'

Many words in which /iN/ → /ɨN/, such as *îmbrăca* above, come from the Latin prefix *in*, a common verbal prefix. This shows backing of /i/ → /ɨ/. It is overly complex to assume that /i/ first lowered and backed to /ʌ/ before raising again to /ɨ/; the vowel /i/ may have become /ɨ/ under analogy to the other instances of /ɨN/. Another analysis, however, is that word-initially, Latin /in/ became the "archiphoneme N," which was realized either as a syllabic nasal or as /ʌN/, and later as /ɨN/ (Rosetti 1973b:80). In Common Romanian, Rosetti argues, this prefix would have been either /ʌN/ or /N̩/, where the latter represents a different treatment of word-initial vowels from word-internal vowels, including the fact that in this context /ɨ/ is not under stress. Examples of this common change appear in (2.14). Back vowels can also be fronted and, in the case of /o/, raised to /ɨ/, as in (2.15); and high back /u/ can centralize to /ɨ/, as seen in (2.16).

(2.14)   /#iN/ → (/#N̩/) → /#ɨN/:

Latin	Romanian		
impedicat	împiedică	/ɨmpjedikʌ/	'impedes'
imperator	împărat	/ɨmpʌrat/	'emperor'
in	în	/ɨn/	'in'

| incantat | încântă | /ɨnkɨntʌ/ | 'delights' (vb) |
| *invitiare | învăţa | /ɨnvʌˈtsa/ | 'learn' |

(2.15)   Latin /o/ → /ɨ/

Latin	Romanian		
*caronia	cărâie	/kʌrɨje/	'carrion'
longu	lângă	/lɨngʌ/	'beside, near'
fontana	fântână	/fɨntɨnʌ/	'fountain'

(2.16)   Latin /u/ → /ɨ/

Latin	Romanian		
*summicella	sâmcea	/sɨmtʃe̞a/	'peak, point'
aduncus	adânc	/adɨnk/	'deep'
axungia	osânză	/osɨnzʌ/	'lard'

2.2.3. Other sources for /ɨ/ in native Romanian words

In native Romanian vocabulary, we also find words in which /ɨ/ is triggered before /rC/ or after /r/.[8] Petrucci (1999) formulates these processes as in (2.17) and (2.18).

(2.17)   /*ʌ/ → /ɨ/ / ____ rC

(2.18)   /i/ → /ɨ/ / r___   (adapted from Petrucci 1999:65)

---

[8] Petrucci (1999) proposes a third rule, namely that /ɨ/ is conditioned before /s/ in native words. I disagree that this process was built on the Latin vocabulary of the language. The only examples Petrucci provides of this rule's application are *câstiga*, which he glosses as 'vigilant,' although it means 'win, earn'; and *râs* 'lynx' – which would follow from (18). Other words containing /ɨs/ in Romanian tend to be of Slavic origin, suggesting that /ɨs/ was *not* originally a native tendency.

In transcribing (2.18), above, I have shown /*ʌ/ as reconstructed, and not attested. Examples of these two rules are seen in (2.19) and (2.20), which in fact assume that /e/ became /ʌ/ before /rC/.

(2.19)   /V/ → /ɨ/ before /rC/:

Latin	Romanian		
marcidu	mârced	/mɨrtʃed/	'rotten'
*carnaceu	cârnat	/kɨrnat/	'sausage'
*fratratu	fârtat	/fɨrtat/	'close friend'
tardivu	târziu	/tɨrziw/	'late'
pergola	pârghie	/pɨrgie/	'lever'
*coturnicula	potârniche	/potɨrnike/	'partridge'
coopertoriu	cârpător	/kɨrpʌtor/	'cutting board'
virtute[9]	vârtute	/vɨrtute/	'virtue'
*cercellu	cârcel	/kɨrtʃel/	'cramp, tendril'

(2.20)   /V/ → /ɨ/ after /r/:

Latin	Romanian		
ridet	râde	/rɨde/	'laughs'
ripa	râpă	/rɨpʌ/	'abyss'
*horritu	urât	/urɨt/	'plain, ugly'
rivu, riu	râu	/rɨw/	'river'
risu	râs	/rɨs/	'laugh'

---

[9] Petrucci (1999:65) reconstructs this word as *vərtute in Common Romanian.

In *fârtat* (2.19), we find metathesis of /r/ and the vowel. Similar processes are also quite common in words from Slavic.

To summarize: in virtually *all* native words containing /ɨ/, the presence of /ɨ/ is explained by the rules in (2.7), (2.17) and (2.18), which derive [ɨ] from Latin vowels. The main source vowel was /a/ in pre-nasal position, but other vowels were also affected. Some words from Latin show /ɨ/ as triggered before /rC/ and after /r/. A handful of phonological rules suffice to account for the distribution of /ɨ/ in native words, strongly suggesting that early in the history of Romanian, prior to extensive borrowings, [ɨ] was an allophone among six phonemic vowels. This indicates that while native words may have been the original source for [ɨ], they are not responsible for its contrastiveness.

2.3. Historical sources for /ɨ/: Words from Old Slavic etymons

Next I examine Romanian words borrowed and adapted from Slavic, a source of loanwords which contributes (Friesner 2009) to the core vocabulary of Romanian. These borrowings expanded the set of environments for [ɨ] in Romanian, pushing the vowel towards phonemic status. Slavic influence on Romanian began during the Common Romanian period (Rosetti 1973b:79), although the greatest influence came during the 12th Century, from South Slavic languages such as Bulgarian. Many Romanian words of Slavic origin have /ɨ/ that corresponds to Slavic < ą >, or /ã/ (Rosetti 1958). A second large group of words appears to have undergone a kind of metathesis, in which an Old Church Slavonic (OCS) word beginning with an onset cluster of /ClV/ or /CrV/ emerges in Romanian as /Cɨl/ or /Cɨr/ (Rosetti 1958). I show below that the set of Slavic vowels which produce Romanian /ɨ/ extends well beyond those listed by Rosetti (1958).

The adaptations of Slavic words that contain /ɨ/ in Romanian can, for the most part, be described by the rules listed in Petrucci (1999) and in (2.7), (2.17) and (2.18). However, Petrucci does not fully describe the conditions under which Slavic words are adapted with Romanian /ɨ/: a subset of the data involve /l/, which Petrucci does not mention in his rules, and which is *not* a conditioning environment for /ɨ/ in native words.[10] While I agree with Rosetti (1986) and Vasiliu (1968) that /ɨ/ was not a phoneme until well after most Slavic borrowings had entered the language, their adaptation into Romanian demonstrates an expansion of [ɨ] beyond its native allophonic environments.

2.3.1. Old Slavic nasalized vowels

Two nasalized vowels from Slavic appear in Romanian as /ɨN/, in which the nasal consonant is homorganic with any following consonant. The first vowel is written either < ą > or < ǫ >; these represent the same sound, a merging of /o/ and /a/ before a nasal. The other is < ę >, a nasalized front vowel. Since the main conditioning environment for /ɨ/ in native words is a following nasal consonant, these Slavic borrowings are not surprising. Rather than producing nasalized vowels or deleting the nasalization, speakers of Romanian adapted these words as *vowel + nasal consonant*, as seen in (2.21). Notice that /ɨN/ appears in place of a nasal vowel regardless of stress. In native words, pre-nasal raising occurs only in stressed syllables; these words show /ɨ/ in unstressed syllables, representing a departure from native raising conditions.

---

[10] Note that we need not take Romanian *vâltoare* 'whirlpool,' from Latin *voltoria, to be an exception to this generalization. This token can also be explained by a tendency for /ɨ/ to appear after a labial consonant.

(2.21)   Slavic nasalized vowels → Romanian /ɨ/

Old Slavic	Romanian		
gąsakŭ	gânsac	/gɨnˈsak/	'gander'
mądrŭ	mândri	/mɨnˈdri/	'take pride'
pąditi	pândi	/pɨnˈdi/	'watch' (vb)
tąpŭ	tâmpit	/tɨmˈpit/	'stupid'
tąziti	tânji	/tɨnˈʒi/	'languish, pine for'
ząbŭ	zâmbi	/zɨmˈbi/	'smile at'
trątiti	trânti	/trɨnˈti/	'fling, throw'
rąka	râncă	/ˈrɨnkʌ/	'cow's vein'
sąsěkŭ	sâsâiac	/sɨsɨˈjak/	'hut for drying grains'
kǫsŭ	câş	/ˈkɨs/	'shoo!'

However, /ɨN/ is not the only Romanian output of Slavic nasalized vowels. Rosetti (1986) explains that Slavic /õ/ receives two treatments in Romanian: older borrowings entered as /um/, /un/, while later borrowings have /ɨn/, /ɨm/. Examples are *kǫpona > cumpănă* /kumpʌnʌ/ 'scales, balance' vs. *tǫpanŭ > tâmpăna / întâmpăna* /tɨmpʌna, ɨntimpʌna/ 'meet, encounter.' Rosetti shows that the older borrowings (which also have /u/ in other languages like Greek and Hungarian) came from Old Slavic, while later borrowings probably came from South Slavic, particularly Bulgarian: there, nasalized vowels developed into /ʌN/, creating an environment for Romanian /ɨ/. Rosetti (1973b:158) argues that these borrowings occurred after the 12th Century, during or just after the period of heaviest influence from Slavic. Even though Bulgarian developed /ʌN/ sequences, Romanian phonology used /ɨN/, suggesting that pre-nasal raising was still active at that time.

Slavic < ę > also has a dual treatment in Romanian: /ẽ/ becomes /in/ when the following syllable contains a front vowel, as in *pętĭno* > *pinten* 'spur (n.)', but /ẽ/ > /ɨn/ otherwise (Rosetti 1986:312).[11] However, this latter rule doesn't always hold, meaning that sometimes the outcome in Romanian is /in/ when /ɨn/ is expected. Additionally, metaphony can work on these forms, so that they have /ɨn/ in the singular, but the word-final plural markers /i/ and /e/ trigger /in/ in the plural. Words in which Slavic /ẽ/ emerges as /ɨ/ include:

(2.22)　　Slavic /ẽ/ → Romanian /ɨ/

Old Slavic	Romanian		
osęditi	osândă	/osɨndʌ/	'sentence'
potęgŭ	potâng	/potɨng/	'plow chain'
rędŭ	rând	/rɨnd/	'line, queue'
svętu	sfânt	/sfɨnt/	'saint, holy'

2.3.2. Romanian treatment of Old Slavic liquid-jer metathesis

In Old Slavic loanwords, speakers of Romanian confronted vowels that were unlike their native vowels; these were the Slavic jers, the front jer < ĭ > or < ь > and the back jer < ŭ > or < ъ >. We know that historically between the Common Slavic period and the earliest written forms of these words (in Old Church Slavonic), these jers underwent liquid-jer metathesis in the Slavic languages, a process which eliminated syllable codas in favor of complex onsets.

While etymological dictionaries (Cioranescu 2002) show Old Church Slavonic forms as the etymons for words borrowed into Romanian, we can in fact see that these words were borrowed prior to liquid-jer metathesis, because the Romanian forms

---

[11] This tendency may result from the Labial Effect, which triggers centralization of /i/ to /ɨ/.

contain the sequence /CɨR/ rather than /CRɨ/. A collation of each Romanian form against its Common Slavic root reveals that all but a handful of Romanian /CɨRC/ words come from words that originally had the form CъRC and eventually underwent metathesis. Thus Romanian borrowed the pre-metathesized forms during its contact with the Slavic languages, which began as early as the 7th Century. These borrowings comprise two groups: words involving /r/ (2.23), and those involving /l/ (2.24).[12]

(2.23)   Old Slavic → Romanian /ɨr/

*Common Slavic	Attested OCS	Romanian		
*kъrma	krŭma	cârmă	/kɨrmʌ/	'helm'
*gъrb	gŭrbŭ	gârbă	/gɨrbʌ/	'hump'
*ne-sъ-vьrš-i-ti	sŭvrŭšiti	nesfârşit	/nesfɨrʃit/	'endless'
*o-sьrd-ьce	osrŭdije	osârdie	/osɨrdie/	'concern, care'
*skъrb-ь	skrŭbĭ	scârbă	/skɨrbʌ/	'disgust'
*smьrd-ъ	smrŭdŭ	smârd	/smɨrd/	'nasty'
*tьrnъ	trŭnŭ	târn	/tɨrn/	'thorn'
*zьrno	zrŭno	zârnă	/zɨrnʌ/	'grain'
*vьrtъръ	vrŭtŭpŭ	hârtop	/hɨrtop/	'pothole'

(2.24)   Old Slavic → Romanian /ɨl/

*Common Slavic	Attested OCS	Romanian		
*stъlp-	stlŭpŭ	stâlp	/stɨlp/	'pillar'
*tъlk-	tlŭkŭ	tâlc	/tɨlk/	'meaning, sense'
*vъlv-	vlŭchva	vâlvă	/vɨlvʌ/	'sensation, stir'
*mъlk-	mlŭkŭ	mâlc	/mɨlk/	'Shh!'

---

[12] A full list of the jer-liquid words I examined appears in Appendix A.

43

*gъlk-ъ	glŭkŭ	gâlceavă	/gɨltʃe̯avʌ/	'fight, quarrel'
*xъlm-ъ	chlŭmŭ	gâlmă	/gɨlmʌ/	'small hill, swelling'

In this data set, Romanian /ɨ/ corresponds only to the Old Slavic back jer < ъ >. This is probably connected with the back-vowel articulation of the jer, which however was not rounded, meaning that it sounded different from /u/ and /o/, the back vowels in Romanian. Rather than create an unrounded back vowel, the language used its centralized counterpart, which emerges as /ɨ/ in modern Romanian. Interestingly, /ɨ/ occurs not only before /rC/, a known conditioning environment, but also before /l/. This is a situation not accounted for by Petrucci (1999), and it represents a significant expansion in the domain of [ɨ]. The use of [ɨ] in this context was probably phonetically motivated, as Romanians adapted Slavic < ъ > to their language; but such a change gave [ɨ] a greater chance to contrast with other vowels. Other Old Slavic borrowings also give /ɨ/ before /l/; for example, *galka > gâlcă* /gɨlkʌ/ 'swelling'; *pochilŭ > pocâlti* /pokɨlti/ 'become thin'; Polish *mul > mâl* /mɨl/ 'riverbank'; and *flĭkavŭ > fâicav* /fɨjkav/ 'stuttering.'[13]

2.3.3. Other Old Slavic sources for Romanian /ɨ/

Other Slavic vowels that produced /ɨ/ in Romanian include /e/ (shown in (2.25)) and < y >, the Slavic phoneme /ɨ/. Additionally, some words are not explained by the phonological processes seen so far.

Some words had /e/ in Old Slavic but show Romanian /ɨ/. These words reflect another set of patterns in the distribution of /ɨ/ in Romanian: first, that /ɨ/ is often

---

[13] Another scenario is one in which Romanian borrowed the forms from South Slavic while the liquid-vowel sequence was in fact a syllabic sonorant, which allows a parallel analysis with word-initial /in/ sequences from Latin. Two examples in favor of this analysis are Slovenian *brdce* > Romanian *bârsă* 'plow beam' and Russian *bzdryt* > Romanian *bâzdări* 'flee.'

44

preceded by a labial consonant; and secondly, that /ɨ/ is often followed by /rV/ (rather than /rC/). These generalizations also hold for some Latin data, although changes involving preceding labials and following /r/ can be sporadic. Some scholars (Vasiliu 1968; Rosetti 1986) point out that labial consonants play a role in conditioning some Romanian vowels, including /ɨ/, but in most such words there is some additional known conditioning factor supporting the presence of /ɨ/. In (2.25), words like *mâzgă* and *mâzgăli* do not conform to Petrucci's (1999) set of rules for the emergence of /ɨ/: his rules include the following environment /s/, but here we see /z/, as in the pair *mizda > mâzdă* 'bribe-money.' These words may indicate that [ɨ] was growing independent from /ʌ/, and could appear in more contexts.

(2.25) Slavic /e/ → Romanian /ɨ/

Old Slavic	Romanian		
mezga	mâzgă	/mɨzgʌ/	'moss, slime'
mezga	mâzgăli	/mɨzgʌli/	'scribble'
kermuš	cârmoaje	/kɨrmo̯aʒe/	'heel of bread'
veslo	vâslă	/vɨslʌ/	'oar'
bezŭ dychaninŭ	bâzdâganie	/bɨzdɨganie/	'monster'

Another Old Slavic source vowel for Romanian /ɨ/ is < y >. According to Petrucci (1999:67), < y > in Old Slavic etymons is /ɨ/, hence a few examples show a direct correspondence between the vowels in the etymon and borrowed form. However, Petrucci argues that these words were originally borrowed with /i/, which later backed to /ɨ/ under the normal phonological conditions of Romanian. Rosetti (1986:307) points out that Slavic < y > gives both /i/ and /ɨ/ in Romanian, meaning that this supposed backing did not occur uniformly. More importantly, there are

several examples of Slavic borrowings with the correspondence < y > – /ɨ/ that cannot be explained by Petrucci's rules. This suggests either that one cannot propose Slavic /ɨ/ → Romanian /i/ → /ɨ/ without expanding the set of conditions for /ɨ/; or that Romanian began to borrow /ɨ/ directly from the Slavic languages. Words with the correspondence < y > – /ɨ/ are in (2.26).

(2.26)   Slavic < y > → Romanian /ɨ/:

Old Slavic   Romanian

rykŭ	râcă	/rɨkʌ/	'argument'
rybĭnikŭ	râmnic	/rɨmnik/	'fish hatchery, fishpond'
rysŭ	râs	/rɨs/	'lynx'
dobyti, dobǫdǫ	dobândi	/dobɨndi/	'obtain'
rylĭcĭ	hârleţ	/hɨrlets/	'spade'
pyşanŭ	pâşen	/pɨʃen/	'haughty'
bezŭ dychaninŭ	bâzdâganie	/bɨzdɨganie/	'monster'
bylije	bâlie	/bɨlie/	'washbasin'
sylĭce	sâlţă	/sɨltsʌ/	'jam-knot'
xytrŭ	hâtru	/hɨtru/	'cunning'

In these data, Romanian *râcă*, *râmnic*, and *râs* have an initial /r/ to condition /ɨ/, while *dobândi* may have had a nasalized vowel in Slavic, and *hârleţ* shows /rC/ after /ɨ/, as noted by Petrucci (1999:67). However, the other words in (2.26) cannot be explained by the rules at our disposal; particularly unexpected by Petrucci's rules is the correspondence *bezŭ dychaninŭ > bâzdâganie*, in which < y > → /ɨ/ between an alveolar and a velar stop. Without appealing to a direct borrowing of /ɨ/ from Slavic, it

is difficult to see how /ɨ/ arose in Romanian. In Romanian *bâlie* and *sâlţă*, /ɨ/ appears before /l/. Finally, Romanian *pâşen* /pɨʃen/ is not explained by Petrucci's (1999) rules.

I have already shown instances of /ɨ/ that cannot be explained by the phonological conditions that produced it in native Romanian words. Among Romanian borrowings from Old Slavic, other words cannot be explained by phonological conditioning or a correspondence of vowel quality. These words represent the gradual expansion of /ɨ/ beyond its limited phonologically conditioned set of environments.

(2.27)   Otherwise unexplained words from Old Slavic

Old Slavic	Romanian		
bŭtŭ	bâtă	/bɨtʌ/	'stick, club'
chudŭ	hâd	/hɨd/	'hideous'
kŭbilŭ	câbla	/kɨblʌ/	'measure of grain'
dira	dâră	/dɨrʌ/	'track, trace'
gidija	gâde	/gɨde/	'assassin'
dikŭ	dâcă	/dɨkʌ/	'fury'
*mĭgla	mâglă	/mɨglʌ/	'stack'
pĭklŭ	pâclă	/pɨklʌ/	'haze, mist'

In (2.27) Romanian /ɨ/ corresponds to several Old Slavic vowels: < u >, < i >, and the jers < ŭ > and < ĭ >. The first two are high vowels, like /ɨ/, which may explain their outcome in Romanian. If the original vowel quality was somehow distorted or unexpected to Romanian speakers, /ɨ/ may have been the closest match. In these words, /ɨ/ cannot be explained by the rules in Petrucci (1999), i.e. a following nasal consonant or nasal vowel, a preceding /r/ or following /rC/. Examples like those in

(2.27) are additional evidence that as Slavic words were adopted into the Romanian lexicon, they affected the phonology by expanding the domain of /ɨ/.

2.3.4. The use of /ɨ/ in Romanian infinitives

Modern Romanian has a set of infinitives that end in stressed /ɨ/, most of which come from Slavic sources (Alkire & Rosen 2010); the native ones belonged originally to the conjugation whose infinitives end in stressed /i/,[14] descendants of Latin fourth-conjugation verbs. In the Old Slavic verbs in (2.28), <ti> is the ending for the citation form, but this does not appear in the Romanian data; instead, the Romanian forms end in /rɨ/, showing the phonological trigger /r/ for Romanian final /ɨ/. Borrowers probably did not base Romanian forms on the Slavic infinitive, but instead borrowed based on a conjugated form, so <ti> does not appear in these forms. However, the fact that the Slavic infinitives end in <i> may help explain why Romanian assigned these verbs to the fourth conjugation in Romanian. The Romanian borrowings are based on the verbal stem, which includes the /r/ seen in these verbs; the stem is the verbal root, and the verb morphologically goes into the fourth conjugation. While /ɨ/ is not phonologically surprising where it is preceded by /r/ in infinitives, this data set demonstrates the expansion of [ɨ] well beyond the original realm of /ʌ/, which included stressed vowels only when a nasal followed.

In several verbs below, such as Romanian *odorî* and *omorî*, Slavic /ri/ corresponds to Romanian /rɨ/. However, in verbs like *târî*, the situation is more complex. Epenthesis of /ɨ/ occurred in the first syllable of Old Slavic *trěti*, and < ě > was syncopated, leaving the form with a final <r> to which Romanian added /ɨ/. The pair *odorati* → *odorî* provides evidence that Romanian based these borrowings on the verb root only. In (2.28) and (2.29), I compare the results of borrowing Slavic verbs

---

[14] The final *–re* of Latin infinitives deletes in Romanian: *dormire > a dormi* 'sleep.'

with stem-final /r/, and those without it: in the first case, the Romanian infinitives end in /ɨ/; in the second, they end in /i/.

(2.28)   Verbs from Old Slavic that end in /ɨ/ in Romanian

<u>Old Slavic</u>   <u>Romanian</u>

Old Slavic	Romanian		
trěti, trą	târî	/tɨrɨ/	'drag'
odorati	odorî	/odorɨ/	'finish a task'
okarjati	ocărî	/okʌrɨ/	'abuse, revile'
izgorěti	izgorî	/izgorɨ/	'ferment grain'
vrěti	vârî	/vɨrɨ/	'push'
prěti, prją	pârî	/pɨrɨ/	'tell on someone'
pasmurětĭ	posomorî	/posomorɨ/	'darken'
oboriti	doborî	/doborɨ/	'take down'
oboriti	oborî	/oborɨ/	'beat to the ground, kill'
umoriti	omorî	/omorɨ/	'kill'
zamoriti	zămorî	/zʌmorɨ/	'consume (food, water)'
pogorĭ	coborî	/koborɨ/	'descend'

(2.29)   Verbs from Old Slavic that end in /i/ in Romanian

<u>Old Slavic</u>   <u>Romanian</u>

Old Slavic	Romanian		
pochilŭ	pocâlti	/pokɨlti/	'become thin'
poplŭniti	popâlni	/popɨlni/	'fill (to overflowing)'
brkati	bârcâi	/bɨrkɨi/	'soil'
uvrŭšiti	ovârşi	/ovɨrʃi/	'execute'
sŭvrŭšiti	săvârşi	/sʌvɨrʃi/	'perform, complete'
rygati	râgâi	/rɨgɨi/	'burp, belch'

The contrast between these sets of borrowed verbs from Slavic is evidence that stem-final /r/ plays a role in determining the Romanian infinitive, conditioning the appearance of final /ɨ/. As outlined in Chapter 1, morphological factors are intertwined with phonological alternations throughout the Romanian vowel system. With respect to other vowels, /ɨ/ plays a role in few morphological markers, but this is one exception to that tendency: when the sequence /rɨ/ occurs in word-final position, it is dependably part of that verbal paradigm.

2.4. Historical sources for /ɨ/: Modern Slavic loanwords

Romanian has loanwords from both Bulgarian and Serbian. This section considers Romanian words borrowed from these modern Slavic languages.

2.4.1. Bulgarian sources for Romanian /ɨ/

The majority of Bulgarian sources for /ɨ/ in Romanian, in this data set, are transcribed with < ă > as the relevant vowel, which represents /ʌ/. Thus these borrowings involve raising in Romanian; however, without precise chronology of these borrowings vs. the date when /ʌ/ and /ɨ/ became separate phonemes in Romanian, we cannot tell whether they were borrowed with [ʌ] and later underwent raising, or if they have always contained /ɨ/. Examples appear in (2.30).

(2.30)   Bulgarian /ʌ/ → Romanian /ɨ/

Bulgarian	Romanian		
văljanik	vâlnice	/vɨlnitʃe/	'peasant's apron'
gămza	gâmză	/gɨmzʌ/	variety of grape
mărlja	mârli	/mɨrli/	'leap' (vb)
tărkalo	târcol	/tɨrkol/	'round, circle'

50

rămžă	rânjet	/rɨnʒet/	'grin'
gâska	gâscă	/gɨskʌ/	'goose'
păstârnak	păstârnac	/pʌstɨrnak/	'parsnip'

Noteworthy in this data set are the words *vâlnice* and *gâscă*, which are not explained by native phonological processes. However, /ɨ/ in the former may be conditioned by the labial /v/ (see §2.3.4), and *gâscă* 'goose' may be affected by analogy to *gânsac* 'gander' (2.21), whose Slavic etymon had a nasalized vowel.

In several words /a/ in the Bulgarian form corresponds to /ɨ/ in Romanian, seen in (2.31). These tokens could be explained by expanding the set of processes producing /ɨ/, to include labials and /l/, which often appear adjacent to /ɨ/.

(2.31)   Bulgarian /a/ → Romanian /ɨ/

<u>Bulgarian</u>   <u>Romanian</u>

kalbaša	câlbaş	/kɨlbaʃ/	'kielbasa'
mahnuvam	mâhni[15]	/mɨhni/	'sadden, embitter'
batlan	bâtlan	/bɨtlan/	'heron'
razgaljam	răsgâia	/rʌsgɨja/	'nurse, spoil'

Some Bulgarian words containing /i/, /u/, /e/ and < ŭ > exceptionally give /ɨ/ in Romanian (see (2.32)). In *pârleaz*, a reversal in segmental ordering occurs in the first syllable of the Romanian form, with respect to the Bulgarian form. This may indicate that Romanian borrowed the word while Bulgarian had a syllabic sonorant as the nucleus of the syllable, and inserted /ɨ/. In *râni*, /ɨ/ is followed by /n/ in both Bulgarian and Romanian, offering an explanation of nasal backing of /i/ to /ɨ/; in *câršenie*, the

---

[15] This may be an alternate pronunciation and spelling of *măhni*, 'trouble, afflict.'

syllable containing /ɨ/ precedes /rʃ/. In *brâglă* a complex onset appears in the first syllable where there is none in Bulgarian. Here, Romanian may have adopted a form with a syllabic sonorant, but reversed the ordering of segments with respect to modern Bulgarian.

(2.32)   Bulgarian non-central vowels → Romanian /ɨ/

Bulgarian	Romanian		
rina	râni	/rɨni/	'wound, hurt' (vb)
prelĕz	pârleaz	/pɨrlĕaz/	'fence gate'
kuršene	cârşenie	/kɨrʃenie/	'argument'
bŭrdilo	brâglă	/brɨglʌ/	part of a loom

2.4.2. Serbian sources for Romanian /ɨ/

In Romanian borrowings from Serbian, the appearance of /ɨ/ can be accounted for with the current set of phonological conditions: /ɨ/ always appears before /rC/. In most cases, seen in (2.33), /ɨ/ has been inserted to break up a consonant cluster.

(2.33)   Serbian sources for Romanian /ɨ/

Serbian	Romanian		
tronosati	târnosi	/tɨrnosi/	'consecrate'
kovrčica	cofârţă	/kofɨrtsʌ/	'tail, mane'
grlič	gârlici	/gɨrlitʃ/	entrance of a cellar or hut
prč	pârci	/pɨrtʃ/	'billy-goat'
povrnuti	povârni	/povɨrni/	'decline, incline' (vb)
odrenuti	odârni	/odɨrni/	'wean'
zaprtak	zăpârste	/zʌpɨrste/	'baby, youngest child'

zadirati	zădărî	/zʌdʌrɨ/	'hunt, bait' (vb)
volak	vâlcan	/vɨlkan/	'asp' (fish)
suržica	sârjiţă	/sɨrʒitsʌ/	mixture of wheat and barley (crop)

One verb in (2.34), *zădărî*, has joined the class of verbs ending in /ɨ/, as seen in (2.28). In *vâlcan*, where /o/ → /ɨ/, the vowel follows the labial /v/, which might condition /ɨ/.

2.5. Interim conclusions: Romanian borrowings from Slavic languages

In the preceding sections, I have demonstrated the range of environments in which Romanian /ɨ/ emerges from Slavic loanwords, including borrowings from Common Slavic, Old Slavic or Old Church Slavonic, and modern Slavic languages. In most of these words, /ɨ/ can be explained by the same set of phonological processes that apply to create /ɨ/ in native Romanian words. These include pre-nasal raising (often from nasalized vowels in Slavic); raising or backing after /r/, and before /rC/. However, many words cannot be accounted for without expanding the set of phonological conditions helping to trigger /ɨ/, to include at least (2.34).

(2.34) a) V → [ɨ] / __ lC (or RC, i.e. liquid + consonant)

   b) V → [ɨ] / C[+labial] __

   c) V → [ɨ] / __ s

Besides the apparent effect of /l/ and labial consonants, /ɨ/ from Slavic may also be surrounded by alveolar and velar stops; by the fricatives /z/ and /ʃ/; and other environments. Additionally, /ɨ/ occurs in unstressed pre-nasal position, which does not happen in native words.[16] Thus even adding three new processes cannot explain all the

---

[16] An exception to this is initial /*i/ → /ɨ/, explained in §2.2.2.

modern Romanian words that contain /ɨ/. While minimal pairs are not attested from this distant time, to show a split between /ɨ/ and /ʌ/, cases of unexplained /ɨ/ indicate that it must have become underlying, rather than allophonic.

These findings contrast with the native words that contain /ɨ/, which can be explained by the rules in (2.7), (2.17) and (2.18) with few exceptions. I argue that the Slavic layer of the Romanian lexicon represents a stage in the historical development of Romanian in which [ɨ] was used more extensively than in native words, causing its domain to expand from a simple allophone of /ʌ/, and move towards phonemic status. However, I am not proposing that [ɨ] was already a phoneme by the end of the 13th Century, when the period of greatest influence from the Slavic languages ended. Only by the 16th Century and later is there definitive evidence that /ʌ/ and /ɨ/ were separate phonemes.

2.6. Hungarian loanwords in Romanian

Among Hungarian loanwords containing /ɨ/, nearly all can be explained by Petrucci's (1999) rules; a few require the rules in (2.34). Rosetti (1958) describes a tendency for Hungarian /a/ to enter Romanian as /ɨ/, but more often I find examples of /o/ → /ɨ/, which Rosetti does not mention. From Hungarian, we find pre-nasal raising to /ɨ/, and /ɨ/ often precedes /r/, or follows a labial consonant.

(2.35)   Raising before /n/

Hungarian	Romanian		
rantas	rântaş	/rɨntaʃ/	'roux'
szarandok	sărântoc	/sʌrɨntok/	'pilgrim'

habszi	hapsân[17]	/hapsɨn/	'wicked, greedy'
gond	gând	/gɨnd/	'thought'
domb	dâmb	/dɨmb/	'small hill'
bantani	bântui	/bɨntui/	'haunt' (vb)

(2.36)   /ɨ/ before /s/ or /rC/

Hungarian	Romanian		
visla	vâslă	/vɨslʌ/	'oar'
csatorna	ceţârnă	/tʃetsɨrnʌ/	'canal'
koporso	copârşeu	/kopɨrsew/	'coffin'
hordó[18]	hârdău	/hɨrdʌw/	'tub, cowl'
hörcsög	hârciog	/hɨrtʃog/	'hamster'
barnas	bârnaci	/bɨrnatʃ/	'near-black'
csavargo	ciobârcău	/tʃobɨrkʌw/	'vagabond'
parlani	pârlui	/pɨrlui/	'soak (clothing)'
csapat, csoport	ciopârţi	/tʃopɨrtsi/	'chop'
csöbörnek	ciobârnac	/tʃobɨrnak/	'barrel'

(2.37)   Instances of /ɨ/ not explained by native phonological processes

Hungarian	Romanian		
bolcsu	bâlci	/bɨltʃ/	'clay pot'
bator	batâr	/batɨr/	'minimum standard'

---

[17] Romanian inserted a final nasal in this word before raising the vowel to /ɨ/. One possible reason is that this adjective assimilated to a form taken by many native adjectives, which end in *an*, from Latin -ANU. Romanian changed the stress from initial to final in this word, which is additional evidence for its adaptation to native phonology and morphology.

[18] In modern Hungarian, vowel quantity is marked diacritically: <ó> is [o:], <ö> is [ø] and <á> represents [a:].

talální	întâlni	/ɨntɨlni/	'meet, encounter'
csikolto	ciocâlteu	/tʃokɨltew/	'nail'
göb	gâb	/gɨb/	'hump (on one's back)'

Among Hungarian loanwords, only those in (2.37) cannot be immediately explained by the original phonological processes. In Romanian *bâlci*, /ɨ/ is preceded by a labial, which we have seen co-occur with /ɨ/. In several examples /ɨ/ is followed by /lC/; but *batâr* cannot be explained with native phonological rules, unless we expand (2.17) to include the following /r#/ as a trigger for /ɨ/. Romanian *gâb* has no known phonological conditioning environment for /ɨ/. These words provide evidence for a Romanian phoneme /ɨ/, not just an allophone [ɨ].

2.7. Turkish loanwords in Romanian

Turkish influence on Romanian began with their conquest of the Balkan peninsula in the 13th Century (Rosetti 1973a). As Rosetti (1958) notes, Romanian /ɨ/ has three major sources in Turkish loanwords borrowed during the time of Ottoman Turkish. First, Turkish /VN/ produces Romanian /ɨN/, and Turkish /VrC/ also triggers Romanian /ɨ/. Additionally, Turkish /ɨ/ − written < ı > − is borrowed into Romanian as /ɨ/. In this case, /ɨ/ is usually stressed in Romanian. These three conditions often overlap; in many cases, /ɨN/ or /ɨRC/ in Turkish gives the same in Romanian. Examples of /VN/ → /ɨN/ appear in (2.38), and /VrC/ → /ɨrC/ is shown in (2.39).

(2.38)   Turkish /VN/ → Romanian /ɨN/

Turkish	Romanian		
kantar	cântar	/kɨntar/	'balance'
kantarci	cântări	/kɨntʌri/	'weigh'

zemberek	ţâmburuş	/tsɨmburuʃ/	'tongue- or whip-grafting'
sinceb	sângeap	/sɨndʒe̯ap/	'marten-skin'
alım	alâm	/alɨm/	'rent'
anasını	anasână	/anasɨʌ/	'interjection'
tahın	tahân	/tahɨn/	'tahini'
kaldırım	caldarâm	/kaldarɨm/	'cobblestone'

(2.39)   Turkish /VrC/ → Romanian /ɨrC/:

<u>Turkish</u>   <u>Romanian</u>

kırbaç	gârbaci	/gɨrbatʃ/	'whip'
barkuk	bârcoace	/bɨrko̯atʃe/	'centennial cotoneaster (shrub)'
barş	bârş	/bɨrʃ/	'year'
terlik	târlic	/tɨrlik/	'slippers'
sürme	sârmea	/sɨrme̯a/	'antimony'
mirza	mârzac	/mɨrzak/	'Tartary-chief'

The sequence /aN/ in particular does not guarantee an outcome of /ɨN/ in Romanian:
see *anasını*, above, in which only the *stressed* (penultimate) vowel /ɨ/
(< ı >) gives /ɨ/ in Romanian. Another example of this is *angıc* → *angâs* /angɨs/, in
which the unstressed initial vowel does not raise, but the stressed vowel in the second
syllable does continue as /ɨ/ in Romanian. This is consistent with the tendency for pre-
nasal raising in stressed syllables, but the correspondence in vowel qualities is
significant. It demonstrates that when speakers heard a word like Turkish *angıc*, they
heard /ɨ/ as a distinct sound that contrasted with /a/ in the first syllable.

By the time the words in (2.38) and (2.39) were borrowed, /ɨ/ was already
becoming established as a phoneme, separate from and no longer in free variation with

/ʌ/. This is a likely scenario, since Ottoman Turkish was an influence on Romanian later than any Slavic language. It is possible, however, that Turkish influence *helped* /ɨ/ to become its own phoneme in Romanian; speakers already produced the vowel as an allophone of /ʌ/, but an influx of vocabulary from Turkish helped cement /ɨ/ and /ʌ/ as different sounds. Chiţoran (2002b) uses a core-periphery model (Itô & Mester 1995) of the Romanian lexicon, to place Turkish loanwords in a category of partly-assimilated vocabulary, indicating their lesser degree of phonological adaptation with respect to Slavic loans. However, Friesner (2009) gives examples indicating that some Turkish loans were preferentially nativized to a greater degree than others, indicating that a strict categorical division among loanword classes may not be adequate. A higher degree of nativization may be indicative of a greater interaction between the Romanian and Turkish phonologies.

I next present examples of loanwords in which the correspondence of /ɨ/ in Turkish to /ɨ/ in Romanian is clear. The words in (2.40) are unexplainable without pointing out that /ɨ/ simply corresponds to an equivalent vowel in Turkish.

(2.40) Words with only an /ɨ/ − /ɨ/ correspondence:

Turkish | Romanian | |
---|---|---|---
satır | satâr | /satɨr/ | 'chopper, cleaver'
balık | balâc | /balɨk/ | 'Black Sea turbot'
baldır | baldâr | /baldɨr/ | 'cow's stomach'
gıdıklanmak | gâdila | /gɨdila/ | 'tickle'
kılıç | călâci | /kʌlɨtʃ/ | 'sword'
hatır | hatâr | /hatɨr/ | 'favor, grace'
kıst | câşt | /kɨʃt/ | 'installment, partial payment'
kırmız | cârmâz | /kɨrmɨz/ | 'shield-louse'

katır	catâr	/katɨr/	'mule'
kızlar agasi	câzlar-aga	/kɨzlaraga/	'master of eunuchs'
çakı	ceacâie	/tʃe̦akɨje/	'small knife'
çakır	ceacâr	/tʃe̦akɨr/	'squinted' (adj)
çadır	ceadâr	/tʃe̦adɨr/	'green military tent'
şatır	şatâr	/ʃatɨr/	'armed guard'
kışla	câşlă	/kɨʃlʌ/	'winter camp'
sakız	sacâz	/sakɨz/	'mastic, bow resin'
kalabalık	calabalâc	/kalabalɨk/	'belongings, chattel'
agirlık	agarlâc	/agarlɨk/	'luggage, baggage'
balık kız	balcâz	/balkɨz/	'obese, swollen'
babalık	babalâc	/babalɨk/	'old'
berbelık	berbelâc	/berbelɨk/	'razor'
çarklı	cearclâu	/tʃe̦arklɨw/	'duchy'
hamailı	hamailâu	/hamajlɨw/	'amulet'
yarlık	iarlâc	/jarlɨk/	'orders, papers'
telhıs	talhâs	/talhɨs/	'functionary's report'

In (2.40), there is a tendency for Romanian /ɨ/ to appear in the vicinity of the liquids /r/ and /l/. However, when /ɨ/ appears before an /r/ in these words, it is not the environment /rC/; therefore these represent an expansion of the phonological environments available to /ɨ/ in Romanian, beyond those expressed in (2.17). Additionally, the presence of /ɨr#/ sequences, as opposed to /ɨrC/ sequences, is more frequent in these later borrowings from Turkish than it was in the (older) Slavic borrowings seen earlier. These facts indicate that while Romanian did not distinguish between the phonemes /ɨ/ and /ʌ/ when the words in (2.40) entered its lexicon,

59

speakers of the language retained vowels faithful to Turkish forms long enough for them to be expressed as /ɨ/ in the modern language. If they had not done so, /ɨ/ should not appear in the words in (2.40), since they do not contain any known conditioning environments for the vowel. Such a perspective is supported, for example, by the tendency for Turkish words to be adapted less to Romanian phonology than other, older loans (Friesner 2009).

2.8.   Interim conclusions: Etymological sources for Romanian /ɨ/

Where /ɨ/ appears in borrowings in Romanian, scholars have disagreed whether the vowel was selected to match its quality in the donor language, or or whether its appearance is a result of phonological conditioning internal to Romanian. Petrucci (1999) takes the latter stance, arguing specifically that /ɨ/ cannot have come from Slavic because words that are traditionally presented as source words for /ɨ/ (Rosetti 1958; Hall 1974) do not actually have this vowel in Slavic. I agree with Petrucci that /ɨ/ did not strictly emerge from a single source language, and that Romanian phonology is at work as well. However, I argue that Romanian /ɨ/ began in allophony with /ʌ/, as is clearly seen in native vocabulary, and gradually expanded to phonemic status with support from borrowings, whereas Petrucci argues that the change was essentially a native process with few exceptions to the phonological restrictions.

In the preceding sections, I have demonstrated that native Romanian words show /ɨ/ in a very restricted set of conditions – specifically, /ɨ/ results from pre-nasal raising, after /r/, or before /rC/. Words from Slavic languages mostly comply with these rules, but in words of Slavic origin /ɨ/ also occurs before /l/ frequently, and there is a set of words in which /ɨ/ cannot be explained. These borrowings, which occurred as early as the 7th Century and continued at least through the 12th Century, helped to push the Romanian vowel system towards a split of [ʌ] and [ɨ] into /ʌ/ and /ɨ/. Words

60

from Turkish, which entered the language no earlier than the 13th Century, also provide evidence that /ɨ/ was becoming contrastive. In a large set of words Romanian /ɨ/ can be attributed to an identical vowel in the Turkish form – but *not* to any conditioning phonological environment.

While I acknowledge that /ɨ/ did not become a phoneme until the 16th Century, there are texts written in the Cyrillic alphabet from the 13th Century and later that show spellings of Romanian words in which /a/, [ʌ] and [ɨ] are separate entities (Rosetti 1973b:92–93). These spellings do not prove that these three phonemes already existed in Romanian; but the letters corresponding to /ɨ/ were used differently in different dialects, usually in conjunction with a nasal. This indicates awareness of a pronunciation difference,[19] which may be an important signpost on the road to contrastiveness. In the next section, I lay out the evidence that /ɨ/ is indeed phonemic synchronically.

2.9.   The phonemic status of /ɨ/

I have provided evidence that in the early history of Romanian, several phonological processes gave rise to [ɨ] in its allophonic form. In the modern language /ɨ/ is a phoneme, but it retains many characteristics of an allophone. This subsection takes a more in-depth look at the environments where /ɨ/ is contrastive; for further discussion see also §3.3.

---

[19] Regarding the split of /ɨ/ from /ʌ/, Vasiliu (1968:128) concludes that /ɨ/ became a phoneme at different times within the Daco-Romanian dialects. In the Muntean dialects of southeastern Romania, including Bucharest, /ɨ/ became a phoneme prior to the 16th Century. In Moldovan dialects further to the north, /ɨ/ became a phoneme only after the 16th Century. Vasiliu bases this on the relative timing of sound changes known to have taken place around the 16th Century. It is possible that /ɨ/ developed as a phoneme earlier in the south due to its greater vicinity to Turkey and thus had greater contact with the Turkish language, which as we have seen makes frequent use of [ɨ].

2.9.1. Minimal pairs

Today, the phonemic status of both /ʌ/ and /ɨ/ is confirmed by a few minimal pairs (Coteanu 1981:12), seen in (2.41).

(2.41)   Minimal pairs: /ʌ/ vs. /ɨ/

/ʌ/   /ɨ/

rău   /rʌw/   'bad'   râu   /rɨw/   'river'

ţări   /tsʌrʲ/   'lands'   ţâri   /tsɨrʲ/   'sea mackerels'

văr   /vʌr/   'cousin'   vâr   /vɨr/   'I thrust'

These pairs can be explained by exploring the phonological changes that occurred between the etymon and the synchronic form. In the first pair, *rău* emerges from Latin *reus* 'bad'. The final /s/ is lost, and as a regular phonological process, /e/ centralizes to /ʌ/ following the trilled initial /r/ (Schulte 2005). The case of *râu* is similar; its etymon is Latin *rivus* 'river', whose final /s/ was lost, and the /v/ as well during the Romanian /b-/-/w/ merger (Alkire & Rosen 2010). Vowel centralization after an /r/ occurs in both mid and high vowels, so /ɨ/ arises from centralization of /i/ in that environment.

The pair *ţări – ţâri* arises from a native word and a Greek loan, respectively. In the first, Latin *terra* undergoes several changes. Following Alkire & Rosen (2010), I posit that its stressed /e/ underwent two historical processes. First, it underwent primary diphthongization to /je/. The /e/ of this diphthong is additionally diphthongized to /e̯a/, allowing us to posit the intermediate form /*tje̯ara/. The triphthong underwent regular reduction to /*tjara/, and the glide /j/ triggered palatalization of /t/ to /ts/ and was 'absorbed' into the consonant. This produces the singular *ţară* /tsarʌ/, which under metaphony emerges as /tsʌrʲ/ in the plural. On the

other hand, *țâri* is from Greek *tsiros*; here, /ɨ/ appears before /r/ in word-final position, which I suggest became a conditioning environment for that vowel. An alternative explanation is that when /ɨ/ appears in word-final position, it marks the word's status as a borrowing (Schulte 2005). The final syllable of the Greek etymon was lost, and the Romanian pluralizes to *țâri*.

The first member of the final pair, *văr*, comes from Latin *verus* 'cousin'. There is a class of words in Romanian in which a front vowel centralized (as /e/ → /ʌ/) after a labial, such as *păr* 'hair', *măr* 'apple', *făt* 'boy'. This word fits that paradigm. The verb *vâr*, on the other hand, comes from Slavic *vreti*, a verb which likely underwent liquid-jer metathesis and resulted in the Romanian introduction of /ɨ/, as discussed above in §2.3.2.

2.10.   Roles reserved for /ɨ/

In the modern language, /ɨ/ has a small morphological role compared to other vowels. For example, /ʌ/ in word-final position is a case marker for many feminine singular indefinite forms, meaning that it appears in many words with great frequency in the lexicon, while the morphological role of /ɨ/ is generally limited to the infinitives described in §2.3.4. Additionally /ɨ/ is used in gerund forms for verbs whose infinitives end in stressed /a/, discussed briefly in §3.3. There are several sets of common words in which /ɨ/ does appear, or in which it plays a special role. These include personal pronouns, the Romanian alphabet, and onomatopoeias, each of which is explored in this section.

2.10.1. The use of /ɨ/ in personal pronouns

Despite the small role of /ɨ/ in Romanian morphology, the language puts this vowel to use in personal pronouns. In these words, /ɨ/ acts as a support vowel,

providing a syllabic nucleus for a word that otherwise lacks one. By *support vowel*, I refer to the generally-accepted meaning of this term for a vowel used to give syllabicity. In these pronouns, /ɨ/ is only pronounced where it is needed, and under other conditions it does not surface.

Romanian has several types of direct and indirect object pronouns. Indirect object pronouns may cliticize to an auxiliary verb, as in *mi-au spus* [mjaw.spus] 'they said to me…' In non-periphrastic tenses, however, cliticization is not possible, due to the lack of an auxiliary verb. The pronominal *mi* [mʲ] does not constitute a syllable in Romanian, and in order to have a pronounceable form a supporting /ɨ/ is added, giving the form *îmi* [ɨmʲ] 'to me,' as in *îmi place îngheţată* 'I like ice cream.' In this case it is not surprising that the support vowel is /ɨ/, since it is followed by a nasal. However, pronouns for other persons also use /ɨ/ to support non-cliticized forms, and in those words there is no phonological conditioning environment for /ɨ/, as shown in (2.42). This demonstrates not only the underlying status of /ɨ/, but also its role as a support vowel.

(2.42)   Romanian pronouns containing /ɨ/

Person	Pronoun		
1ˢᵗ person	îmi	[ɨmʲ]	'to me'
2ⁿᵈ person	îţi	[ɨtsʲ]	'to you'
3ʳᵈ person	îi	[ɨj]	'them' (acc); 'to him/her';
			'to them' (masc)
	îl	[ɨl]	'him' (acc)

2.10.2. The use of /ɨ/ in the Romanian alphabet

/ɨ/ also appears as a support vowel in the names of letters in the Romanian alphabet.[20] When reciting the sounds of the alphabet or phonemes, speakers use /ɨ/ in their pronunciation of most consonantal letters, to create a full syllable, as shown in (2.43).[21]

(2.43)   /ɨ/ in the Romanian alphabet

Letter	Pronunciation	Letter	Pronunciation
b	[bɨ]	n	[nɨ]
c	[kɨ]	p	[pɨ]
d	[dɨ]	r	[rɨ]
f	[fɨ]	s	[sɨ]
g	[gɨ]	ş	[ʃɨ]
h	[hɨ]	t	[tɨ]
j	[ʒɨ]	ţ	[tsɨ]
l	[lɨ]	z	[zɨ]
m	[mɨ]		

The instances of /ɨ/ seen in this list are *not* phonologically conditioned: no conditioning environment appears, except in the case of < r > /rɨ/. A central vowel of neutral articulation is a logical choice for this context in Romanian: unlike /i/ or /e/, /ɨ/ does not trigger any changes, like palatalization, that could alter pronunciation of a preceding sound and create ambiguity in the referent of the sound. Recitation of the

---

[20] One native speaker informs me that there is a distinction between the pronunciation of letters for spelling, in which <d> is pronounced [de], and the pronunciation of the sounds themselves, in which /d/ is pronounced [dɨ].
[21] Letters not shown in this list have pronunciations that do not include /ɨ/.

alphabet probably does not occur often in texts or conversation, so these forms have little effect on the vowel's relative frequency, but the fact that /ɨ/ appears here shows the vowel's phonemic status. These citation forms create several minimal pairs with /ʌ/.

(2.44)   Additional minimal pairs of /ʌ/ and /ɨ/

	/ʌ/			/ɨ/	
să	/sʌ/	'that' (conj.)	's'	/sɨ/	
mă	/mʌ/	'me' (acc.)	'm'	/mɨ/	
că	/kʌ/	'that' (conj.)	'c'	/kɨ/	
dă	/dʌ/	'gives'	'd'	/dɨ/	
fă	/fʌ/	'girl!' (interj.)	'f'	/fɨ/	

2.10.3. The use of /ɨ/ in Romanian onomatopoeias

A considerable and productive source for /ɨ/ in Romanian are the language's onomatopoeic verbs, which belong to the fourth (stressed –i) conjugation. Each of these verbs contains two instances of /ɨ/ in the bisyllabic stem, the first of which tends to be followed by an /r/ or /rC/, indicating some phonological conditioning; the other is the penultimate vowel in the word. Examples in (2.45) show that these verbs, whose phonetic form imitates that of the sound or movement they describe, all have similar vocalic content. Only the consonants differ, and in some cases even the consonantal structure is repetitive and hints of reduplication, as in *dârdâi* 'tremble.'

The use of a template for onomatopoeias is not rare in the world's languages. A classic example of phonology at work in onomatopoeic forms is seen in Japanese, whose mimetic system of sound symbolism (Hamano 1998) is extensive and makes use of reduplicative forms. In Japanese, the number of sound-symbolic words is so

66

large that these words have their own phonological, syntactic and semantic patterns (Hamano 1998). In Romanian, on the other hand, the templatic nature of mimetic words is limited.

While I focus on verbs whose main vowel is /ɨ/, Moroianu (1995) includes other onomatopoeic verbs in his description of their form and function; many of his examples use /ʌ/ as their templatic vowel. Moroianu observes the following general characteristics: a) Onomatopoeic verbs do not participate in the morphological alternations (e.g. metaphony) seen throughout most Romanian paradigms. b) The onomatopoeic root is generally formed by two syllables, the first of which is the imitative syllable. c) The onomatopoeic verbs' exact pronunciation tends to vary across regions, with several variants. d) The conjugations of these verbs can be irregular, not strictly following the conventions of one particular verb class, even within a single verb's paradigm. e) Many are used only in the third person, consistent with their use for describing an ambient sound. Moroianu proposes that the rules of Romanian verb morphology are altered for onomatopoeics, to preserve the clarity of the sound they imitate.

A dictionary search found a set of about 70 onomatopoeic verbs using /ɨ/, which appear in Appendix B and are similar in shape to those seen in (2.45) below.

(2.45)   Romanian onomatopoeias

       bâţâi   /bɨtsɨi/   'jerk, shiver'

       cârâi   /kɨrɨi/   'croak'

       dârdâi   /dɨrdɨi/   'tremble, vibrate'

       fâlfâi   /fɨlfɨi/   'flutter'

       fâsâi   /fɨsɨi/   'fizz'

       fâşâi   /fɨʃɨi/   'rustle'

gâgâi	/gɨgɨi/	'gaggle'
hârşâi	/hɨrʃɨi/	'grate'
scârţâi	/skɨrtsɨi/	'squeak, crunch, creak'
ţârâi	/tsɨrɨi/	'chirp, buzz'
vâjâi	/vɨʒɨi/	'have a buzzing in one's ears'
zgâlţâi	/zgɨltsɨi/	'jolt, shake'

While /ɨ/ may be phonologically conditioned in some of these words, as in *scârţâi* 'squeak' or *hârşâi* 'grate,' this list also contains many words that do not obey the rules under which /ɨ/ emerged in native words. Examples are *gâjâi* 'huff, puff,' *sâsâi* 'hiss,' and *bâţâi* 'shiver.' These verbs do not have high token frequency, but their consonantal content demonstrates the full range of environments in which /ɨ/ can appear.

2.11.   Conclusions: /ɨ/

Among the phonemic monophthongs of Romanian, /ɨ/ is the most recent addition, and in Chapter 3 I show that it also has the lowest type frequency. Its development is a result of two vowel splits: first, that of /ʌ/ from /a/, very early in the history of Romanian; and secondly, the split of /ɨ/ from /ʌ/, which occurred only after the two vowels had participated in an allophonic relationship for centuries. I have argued that while /ɨ/ was allophonic in native words, an influx of borrowed words led to its eventual phonemicization.

The different stages of evolution of /ɨ/, from allophone to phoneme, can be seen in three separate sets of words. First are those from Popular Latin, demonstrating the vowel's allophonic beginnings. Words from Slavic also show [ɨ] to be largely conditioned, but in these words the vowel appears in an expanded set of environments,

some of which are not phonologically predictable. One major subset of Slavic borrowings that contain /ɨ/ had nasalized vowels in Old Slavic. Words containing jer-liquid sequences were also adopted with /ɨ/, either in the place of a jer or a syllabic sonorant. The exact chronology of these borrowings is not known, but the choice of /ɨ/ as the vowel in these words indicates its growing importance in the language. Finally, the cementing of /ɨ/ as a phoneme is best captured by loanwords from Turkish, which arrived later than Slavic borrowings, but still before the earliest Romanian texts. These loanwords have not only a direct correspondence between Turkish [ɨ] and Romanian /ɨ/, but also an increased proportion of words in which /ɨ/ cannot be explained by phonological conditioning alone; clearly, it had become available as a rendering for Turkish [ɨ] regardless of conditioning environment. The synchronic phonemic status of /ɨ/ is confirmed by a set of minimal pairs, crucially with /ʌ/, with which it was formerly in an allophonic relationship.

The spread (although not the genesis) of Romanian /ɨ/ may be a product of lexical diffusion (Kiparsky 2003), an analogical process in which a phonological rule is generalized to new contexts, resulting in neutralization. In some examples seen here (see §2.2.2) neutralization indeed occurs; some degree of contrast was lost between vowels in stressed, pre-nasal position as they emerged as /ɨ/ in the modern language. However, this change is not exceptionless; /ɨ/ tends most strongly to appear in this position when the historical etymon had /a/ (or /ʌ/), and less when it contained a peripheral vowel including /i, e, o, u/.

Synchronically, /ɨ/ also appears in pronouns, the alphabet, and onomatopoeias. This suggests that the role of /ɨ/ in Romanian has expanded beyond its original environments, either native or borrowed, and as a phoneme it inhabits a larger portion of the lexicon than it did upon first emerging. This sets the stage for the topic of the next chapter, which investigates the implications of these developments for relative

69

type frequency, and explores the synchronic distribution of /ɨ/. In fact, Chapter 3 shows that despite its presence outside its original phonological conditioning environments, the role of /ɨ/ in Romanian remains narrowly restricted with respect to other vowels, and its distribution is still nearly predictable.

Exploring the development (and synchronic contrastiveness) of phones like Romanian /ɨ/ permits reflection on the question of whether phonology, as a system of contrasts, must be categorical or if it can (also) be gradient. Cohn (2006:26) points out the relevance of historical processes for this debate: "The results of many diachronic changes, understood to be 'regular sound change' in the Neogrammarian sense, are categorical, yet how do changes come about? Are the changes themselves categorical and abrupt or do the changes in progress exhibit gradience and gradual lexical diffusion?" The change of Romanian /ɨ/ from allophone to phoneme was neither categorical nor abrupt; but Chapter 3 shows that the segment's diffusion throughout the synchronic lexicon is incomplete due to the cessation of processes that triggered the vowel's appearances. This example indicates that on an historical scale, changes in a language's system of phonemes can be gradual rather than discrete.

CHAPTER 3: CASE STUDIES IN ROMANIAN TYPE FREQUENCY

3.1. Introduction

What role can a new phoneme play in a language, particularly in how it
contrasts with other phonemes and its level of relative frequency? This chapter
explores that question through two case studies, one focusing on Romanian /ɨ/, whose
emergence as a phoneme is described in Chapter 2; and the other focusing on the
diphthongs /e̯a/ and /o̯a/. It builds upon the historical developments described in the
previous chapter to delineate these vowels' synchronic outcome by examining their
status in the Romanian phonological system. Among my findings is that these vowels
remain *marginally contrastive* in Romanian, meaning that although they are
phonemic, they do not fit within the sharp division usually assumed to hold between
phonemes and allophones: they are conditioned in some aspect, such that their
distribution remains predictable.

A common thread across the two case studies is the importance of borrowings
in expanding the distribution of the vowels in question, each of which first emerged as
a conditioned allophone in the native phonology. In this chapter I explore the
consequences of these marginally contrastive relationships through studies of relative
type frequency across Romanian vowels. These three vowels have certain
characteristics in common: first, their phonemicization was dependent on the influence
of loanwords (as was shown for /ɨ/ in the previous chapter); second, they all have very
low type frequency, which indicates that they have not expanded into large portions of
the lexicon or replaced other vowels to a large extent; finally, their distribution is
restricted. While /ɨ/ is limited to a small range of phonological contexts, in keeping
with its historical conditioning, the diphthongs' role is largely morphologically
determined, meaning that their appearance is for the most part limited to certain

paradigmatically-controlled contexts. Historically, the diphthongs first emerged through metaphonic alternation, which additionally restricts their distribution with respect to word stress and surrounding vocalic context. Although these three vowels are all phonemic in modern Romanian, the restrictions on their distribution mean that they are not as robustly phonemic as other vowels in the language, such as /i/, /e/ and /a/ in particular.

This chapter traces the processes that have largely maintained the predictability of /ɨ/, /e̯a/ and /o̯a/ with respect to the contexts in which they appear, while the acoustic study in Chapter 4 shows how they fit into the vowel system from a phonetic perspective. These morpho-phonological and phonetic studies are coupled with a perceptual investigation (Chapter 4, Appendix C) whose results suggest that vowel identification is affected by marginal contrastiveness, reflecting its potential to affect communication between speaker and hearer.

3.1.1. Marginal contrastiveness in Romanian

Chapter 1 describes the categorical distinction typically assumed to hold between two sounds in a language, which may be considered separate phonemes if minimal pairs exist between them, or allophonic if their distributions are complementary and able to be captured by rules. However, as I point out in that chapter, this divide is not always clear; there is instead ample evidence (Goldsmith 1995; Scobbie 2005; Ladd 2006; Hall 2009) that the relationship between a pair of sounds can fall anywhere along the continuum from allophony to full contrastiveness. Examples of this abound within the literature under a variety of labels (Hall 2009). These case studies in Romanian focus on three phones ([ɨ], [e̯a] and [o̯a]) whose distributions remain highly conditioned and predictable, and which additionally have very low type frequency, meaning that only small numbers of words attest to their

status in the language. In other words, their contrastiveness is marginal because their role in the language is limited with respect to that of higher-frequency phonemes.

What are the defining characteristics of marginal contrast in Romanian? Where /ɨ/ is concerned, Chapter 2 has shown how few minimal pairs separate this vowel from /ʌ/. This is an example of a pair of phonemes (/ɨ/ and /ʌ/) whose *relationship* is marginally contrastive, meaning that few minimal pairs attest to their contrastiveness. This is especially relevant because these two phonemes were once in an allophonic relationship, and the contrast between them may be different from that between historically unrelated vowels. Among Romance languages, a similar case comes from Spanish, which exhibits several instances of "quasi-phonemic" contrast, including one between diphthongs and hiatus sequences (Hualde 2004). This was also explored experimentally (Hualde & Chiţoran 2003; Chiţoran & Hualde 2007); the authors argue that the instances of hiatus have failed to diphthongize because they appear in contexts where their duration is prosodically conditioned to be too long to be perceived as a glide-vowel sequence. Additionally, there may be partial contrasts between glides and obstruents [j] – [ʝ] and taps and trills [ɾ] – [r̄] (Hualde 2004). What all these partial contrasts have in common with Romanian is that in each case, the phones in question contrast in only a few (near) minimal pairs, or in only one prosodic position (for [ɾ] vs. [r̄]). The relationship between the Romanian central vowels is a key motivation for the acoustic study in Chapter 4, and for the perceptual studies discussed in Chapter 4 and Appendix C.

To understand how to conceptualize the relative strength of contrasts among a language's phonemes, a helpful concept is *functional load*. The functional load of a contrast is determined most simply by the number of minimal pairs (or other phonological evidence for the independence of two phonemes) that support the contrast (Hockett 1966). Discussion of functional load is often accompanied by the

idea that contrasts of low functional load might be relevant for sound change (Martinet 1964), although it has been argued that the small functional load of a contrast should not in fact be a driving force for the loss of contrast (King 1967). The more minimal pairs a language has as evidence for a particular contrast, the higher the functional load of that contrast. By this definition, the contrast between /ɨ/ and /ʌ/ in Romanian is one of low functional load, because few lexical contrasts depend on their status as separate phonemes. On the other hand, the functional load of the contrast between /ʌ/ and /a/ is quite high, because the former is used as a marker of indefinite feminine singular forms, while the latter marks the definite (e.g. *casă* /kasʌ/ 'house' vs. *casa* /kasa/ 'the house').

As we have seen for /ɨ/ in Chapter 2 and will see below for /e̯a/ and /o̯a/, the influence of borrowings is integral to the process of phonemicization, and thus these vowels offer a case study into non-binary phonological distinctions. As outlined in Chapter 1, Goldsmith describes "not-yet-integrated semi-contrasts," which include sounds that "contrast in some environments, but which in a particular environment show a sharp asymmetry, in that *x* appears in large numbers, while *y* appears in small numbers in words that are recent and transparent borrowings" (Goldsmith 1995:11). Typical semi-contrasts are those in which a phonotactically restricted sound expands into a new environment under the influence of loanwords; for example, while coronal stops are prohibited before /i/ in native Japanese phonology, they are increasingly permitted there in words borrowed from English (Crawford 2009).

While the Romanian cases resemble this type of semi-contrast, they do not fit neatly into a sub-category along Goldsmith's continuum, precisely because of the competing roles of native phonology and loanwords. As loanwords were adapted using [ɨ] (as well as [e̯a] and [o̯a]), these borrowings not only expanded the vowels' phonotactic boundaries, but also pushed them from allophonic to phonemic status. At

the same time, since these three vowels were originally part of the native phonology, their occurrence does not transparently mark borrowings, which has led to disagreement particularly on the source of /ɨ/, as described in Chapter 2. The combined effects of native conditioning and loanword influences result in lexical contrasts, but at rates that are greatly reduced with respect to contrasts among higher-frequency phonemes with completely unrestricted phonological distributions. The contrast between /ɨ/ and /ʌ/ in particular, we will see, has strong parallels with cases of marginal contrastiveness in other languages, such as that between interdental fricatives /ð/ and /θ/ in English.

3.2.   Frequency of vowels in Romanian

This section gives a picture of the modern Romanian language, in which the role of each vowel is viewed within the current phonological system through an analysis of the frequency with which different sounds occur in the Romanian lexicon. This section facilitates a depiction of marginal contrastiveness resulting from historical allophony, and focuses on /ɨ/, but the analysis also supports a study of /e̯a/ and /o̯a/ later in the chapter. A frequency analysis can help us in two ways to study the roles of vowels: first, it quantifies the role of each member of the vowel system across the lexicon. Do some vowels appear in a large percentage of words, while others appear only occasionally? I find that, in Romanian, this is certainly the case. Secondly, this analysis examines the co-occurrences of different segments with one another – a technique that can indicate the degree to which a particular phoneme is phonologically conditioned by another, if they are frequently adjacent. Indeed, the co-occurrences of Romanian /ɨ/ do show the effects of phonological conditioning.

I begin by looking at the relative frequencies of all segments in Romanian. Examining the frequencies of both vowels and consonants allows us consideration of a

segment's surrounding environment, for example to demonstrate that a particular vowel-consonant pair tends to appear more than others. To show that a co-occurrence is greater than chance, we must consider the frequencies of both members of a pair. For example, /a/ may appear frequently next to /s/, while /o/ appears infrequently with /p/. Rather than assuming that /a/ is conditioned before /s/, we must consider the possibility that /a/ and /s/ are high-frequency segments in the Romanian lexicon, so we expect them to co-occur frequently; while /o/ and /p/ are much less frequent and should thus co-occur much less often.

This section of the chapter focuses on the relevance of type frequency effects for the status of /ɨ/, and the relationship between its historical development and synchronic status. To do this, I examine the footprint of borrowings, and find that beyond the results of the phonological processes that caused raising and backing of Latin vowels to /ɨ/, this vowel has not spread into large portions of the Romanian lexicon. Very few Romanian words contain /ɨ/, and its appearance is often predictable based on its formerly allophonic relationship with /ʌ/. As we have seen, few minimal pairs distinguish the two phonemes, and yet they are contrastive.

This relative frequency analysis lays the groundwork for a deeper examination of phonological environments in Romanian, particularly those relevant for /ɨ/. Together, these analyses reflect the result of the phonological processes discussed in Chapter 2: while /ɨ/ *can* appear in nearly any phonological environment, it tends to appear in pre-nasal position and near /r/, consistent with its allophonic origins. In fact, its distribution reflects little more than the phonological footprint of the vowel's origins.

3.2.1. Type frequency analysis

Presented here is a *type frequency* analysis of phonemes within *word forms*.
Two varieties of frequency counts are commonly used in linguistics: type frequency
and token frequency. These are explored through corpora, in the form of word lists,
documents, transcribed conversations, or other forms of text. The *types* within a text
are abstract categories defined for the purpose of the analysis: here, each of the
phonemes of Romanian represents a type, but one could also look at nouns vs. verbs as
two different types, or strong vs. weak verbs, or even specific words. Within a
particular type, a *token* is a specific instance of that type; for example, Romanian *casa*
/kasa/ contains three phoneme types, /k/, /s/ and /a/, and has two tokens of phoneme
type /a/.

A *word form*, also known as a *lexeme*, is a particular phonological form (Levelt
1989). These lie in contrast to *lemmas*, which are semantically and syntactically
defined lexical entries. The relationship between word forms and lemmas is complex,
because as described in Jurafsky et al. (2002), it is not a one-to-one relationship. For
example, the English word form *bear* or *bare* /beɹ/ is associated with multiple lemmas:
a noun 'large furry mammal', and at least two verbs 'to carry or withstand', or 'to
travel in a certain direction'. At the same time, a lemma can be linked with multiple
word forms, classic examples of which are English *a* and *an* – multiple phonological
forms of the same syntactic and semantic entity – and *the*, which is pronounced in at
least two ways, [ðə] and [ði] (Jurafsky, Bell & Girand 2002:3). My analysis of
Romanian does not classify words by lemma, but instead is based on a word list, in
which each word in the list is different, therefore representing a specific word form.

The source for this frequency analysis is an electronic word list, designed for
journalistic applications such as spell-checking (Vladutu 2009). This list contains
788,157 characters in 88,580 words, which in addition to general word classes (nouns,

verbs, adjectives, etc.) includes some abbreviations, personal names, and proper nouns. The list also includes declined nouns and adjectives, meaning that each noun is listed six times (indefinite, definite, and genitive/dative, both singular and plural); and each adjective is listed six times. For example, the noun meaning 'museum' has six separate entries: *muzeu* and *muzee*, the indefinite singular and plural forms; *muzeul* and *muzeele*, the singular and plural definite forms; *muzeului* and *muzeelor* 'of/to the museum(s).' Verbs also appear in more than one form. The fact that some root words occur more than once means that my analysis slightly over-samples these. Likewise, phonemes within morphemes are sampled each time they appear. Over-sampling of roots and morphological endings does skew my results, by over-counting the segments that are heavily represented in Romanian morphology. Thus my analysis is not a type frequency analysis in the strictest sense, but it is an initial attempt at phoneme type frequency, using the language's orthographic forms instead of phonemic transcriptions. Exploration of this corpus begins with basic statistics on the word list.

(3.1) Word list statistics

Total words	88,580
Total vowel characters	*368,970*
Number of vowels analyzed	355,142[22]
Total consonant characters	419,149
Total characters analyzed	788,119
Total characters	*788,157[23]*

---

[22] This number counts the orthographic transcriptions of the three main diphthongs of Romanian – <ie>, <ea>, <oa> – as one vowel each.

[23] This calculation includes a handful of characters that are not part of the Romanian alphabet, including numerals, vowels with accent marks, etc. These are excluded from the analyses unless otherwise noted.

For the remainder of this discussion, frequencies of particular segment types are discussed in terms of percentages; all percentages of vocalic segments are calculated relative to the number of total vowel characters, and all percentages of consonantal segments are calculated relative to the number of total consonant characters.

The Romanian spelling system has shallow orthographic depth, so an orthographically-transcribed word list (such as I use here) is useable for phonological searching. The transcriptions of vowels are shown in (3.2); the transcription of consonants is also transparent, with the exception of < c > and < g >, shown in (3.3).[24]

(3.2)　　　　Transcription of Romanian vowels

Orthography	Phoneme	Orthography	Phoneme
< a >	/a/	< â > or < î >	/ɨ/
< e >	/e/	< u >	/u/
< ă >	/ʌ/	< ea >	/ja/
< i >	/i/	< oa >	/wa/
< o >	/o/	< ie >	/jɛ/

(3.3)　　　　Transcription of Romanian velar consonants

	< c >	< g >
__ V[+front]	/tʃ/	/dʒ/
Elsewhere	/k/	/g/

---

[24] I have not transformed all segments into an IPA equivalent, because I do not want to imply that my data correspond perfectly to the phonological form.

In Romanian orthography, the segment <j> is a voiced alveo-palatal fricative /ʒ/; < ţ > represents /ts/, and < ş > represents /ʃ/.

Calculations of type frequency were performed using the formula in (3.4), where X represents the segment in question, and Y represents the total number of vowels or consonants, according to whether X is a V or a C.

(3.4) $\dfrac{Count(x)}{Count(Y)}$

3.2.2. Relative frequencies of vowels

First, I calculate overall type frequencies of vowels. In Figure 3.1, the Y-axis shows a count of the total instances of a particular vowel, represented as a percentage of the total number of vowel characters in the word list (as shown in (3.1)).
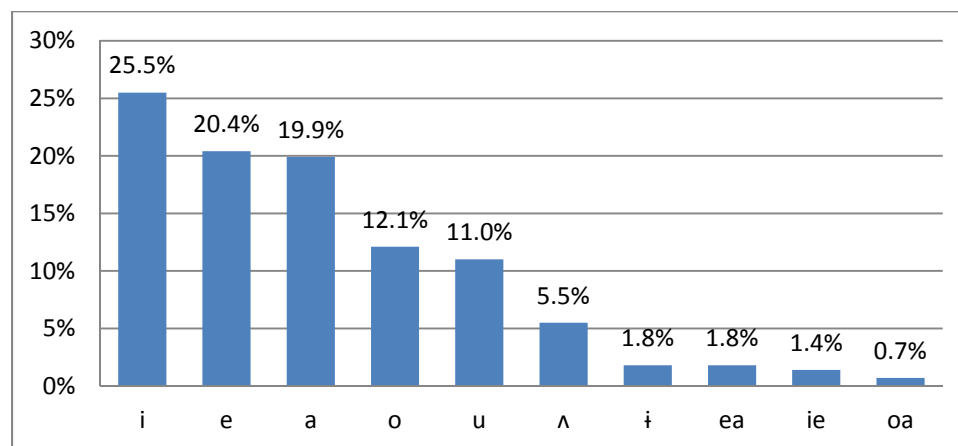
Figure 3.1.   **Romanian vowel frequencies**[25]

---

[25] We will see later in §3.4 that some instances of <ea> (613) and <oa> (189) are in fact vowels in hiatus. This means that in Figure 3.1, the values for /e/, /a/ and /o/ are slightly deflated with respect to what is reflected by the phonological forms, and that the values for <ea> and <oa> are slightly inflated with respect to the occurrence of actual diphthongs.

Figure 3.1 shows that <i> is the most frequent vowel in Romanian, accounting for 25% of vowel characters. While <i> represents the phoneme /i/, it does not always surface as [i]; it appears as a glide, or as a word-final morphological marker, in the masculine plural and some verb conjugations. In these contexts, /i/ surfaces as a palatal [ʲ] unless a full vowel [i] is needed to support a rising-sonority consonant cluster, such as *noştri* [noʃtri] 'ours'. The vowels <a> and <e> are also very frequent in Romanian; together, these three vowels account for 70.1% of the vowels in the word list. <a> and <e> and are frequent morphological markers: among other things, <a> marks the definite form of many feminine singular nouns and a class of verbal infinitives, while <e> occurs within feminine plural endings and in verb forms. <o> accounts for 12.1% of the vowels analyzed here, followed by <u>, at 11.0%. <o> might have higher token frequency: it is the feminine singular indefinite article, which would find frequent use in texts but is not seen here. <u>, on the other hand, is part of the masculine singular definite marker /ul/, which is represented in the current word list.

Among the monophthongal vowels of Romanian, /ʌ/ and /ɨ/ are the least frequent: of all the vowels in this word list, /ʌ/ accounts for 5.5%, while /ɨ/ makes up only 1.8% of the total vowel count. The low type frequencies of both these vowels correlate with the fact that their functional load is characterized by only a few minimal pairs. Both vowels occur in morphological inflections, although /ʌ/ has a more basic role than /ɨ/ in these patterns. /ʌ/ is the non-definite nominative/accusative ending for many feminine singular nouns; compare *casă* /kasʌ/ 'house' with *casa* /kasa/ 'the house.' /ʌ/ appears often in the word list in its inflectional role; it also appears frequently in verb paradigms.

On the other hand, /ɨ/ does not have a role in nominal or adjectival morphology – which all the other vowels do. It marks a subset of 4th conjugation verbs, as

discussed in §2.3.4. Additionally, /ɨ/ is the vowel in the gerund form of verbs whose infinitives end in /a/, such as *încercând* /ɨntʃerkɨnd/ 'testing, trying' from *încerca* /ɨntʃerˈka/ 'try'.[26] From these facts, we can see that the low type frequency of /ɨ/ is not surprising, since its role in morphology is less than that of the other vowels.

The three diphthongs /jɛ/ <ie>, /e̯a/ <ea> and /o̯a/ <oa> also have very low type frequency. The latter two are mainly restricted by metaphony (in which diphthongs alternate with mid vowels), and all three appear only under stress, which greatly reduces the number of syllable nuclei they can fill. Their type frequencies are 1.8% and 0.7%, respectively, reflecting the small number of individual words in which they appear (6,328 for <ea> and 2,613 for <oa>), which facilitates the analysis given in this chapter. I do not further address /jɛ/ here; it appears in native words, but does not have a productive role in morphological endings, nor are the phonological processes that triggered it active. Together, these characteristics indicate that /jɛ/ is a historical remnant of very old sound changes.

The type frequencies and morphological roles of Romanian's phonemic vowels indicate an uneven distribution of labor among the vowels. I will show that in particular, the low type frequency of /ɨ/ correlates with its historical development. Although /ɨ/ can co-occur with nearly all the segments in the Romanian system, it still has characteristics of a phonologically-conditioned allophone. As we have seen, it did not spread much beyond the environments it occupied when it was an allophone. To complete this argument, however, I consider not only type frequency among vowels, but also among consonants.

---

[26] This morphological ending results from one of the native phonological changes that gave rise to /ɨ/ in Romanian: pre-nasal raising of stressed /i/.

3.2.3. Type frequency analysis of consonants

Figure 3.2 shows the type frequencies of Romanian consonants, arranged from least to most sonorous. The counts represented here are shown as a percentage of the total number of consonant characters in the word list.
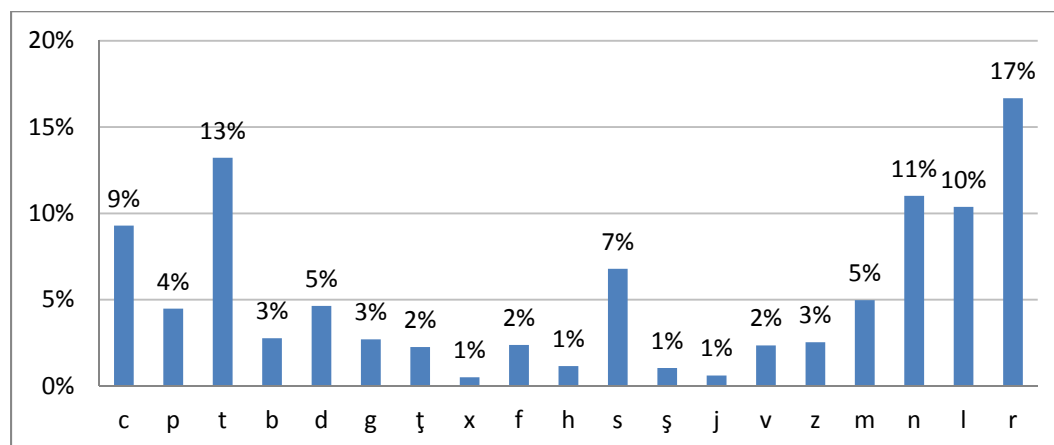
Figure 3.2.　　**Romanian consonant frequencies**[27]

In Figure 3.2, we see that <r> is the most common of the Romanian consonants, making up 16.7% of the total. Close behind are <t>, <n> and <l>, which each make up more than 10% of the consonants in the word list. The segments <c> (/k/ or /tʃ/) and <s> make up 9.3% and 6.8%, respectively, of the consonants; together, these five segments account for 67.4% of the consonants analyzed here, and no other consonant type makes up more than 5% of the total.

Knowing now which consonants in Romanian are the most frequent types, we are better equipped to judge the frequencies with which each consonant type appears adjacent to a given Romanian vowel type. We should not be surprised to see a high number of vowel type /i/ appearing near consonant type /r/ or /n/, for example,

---

[27] This graph excludes 1,947 individual consonant characters, which include non-native or little-used segments such as <q>, <k>, <w>, <y>. The excluded consonants represent a miniscule percentage of the total characters in the word list; only 1,947 out of 788,157.

because all three of these segments are quite frequent in Romanian. On the other hand, if a low-frequency type occurs frequently with another type, their co-occurrence may be more than coincidental. This is the case for /ɨ/.

3.2.4. Romanian vowels and their following segments

This section compares the role of /ɨ/ to that of the other monophthongal vowels by examining the segments that surround them. In the following figures I show the array of segments that appears *after* each of Romanian's phonemic vowels, and I demonstrate that there is a strong relationship between /ɨ/ and a following nasal. No relationship of this magnitude exists between another vowel and a following segment. This correlates with the fact that following nasals were a major conditioning environment for the emergence of /ɨ/ in Romanian phonology. A relationship of this type also exists, albeit to a lesser degree, between /ɨ/ and a following /r/.

The data shown in this section were collected with a computer script to create a database including each instance of each vowel type, with the segments that preceded and followed it. I used statistical analysis software to graph the contents of this database.

Figures 3.3-3.8 are ordered from most frequent to least frequent vowel type: /i/ is shown first, and /ɨ/ last.[28] In these figures, the X-axis shows the array of contexts found after each vowel type, and the number atop each bar is a percentage, for example showing the percentage of /i/'s within the word list that are followed by a particular context; contexts are arranged from lowest to highest sonority. The Y-axis scale shows a count of instances of each following context, represented as a

---

[28] The language's main diphthongs, <ie>, <ea> and <oa>, are not analyzed here. The reason for this exclusion is that the diphthongs do not appear to compete with /ɨ/ for vowel slots. These three diphthongs have accordingly been removed from the remaining figures.

percentage of the total instances of /i/. In these figures, # stands for a word boundary, indicating how often a vowel appears word-finally.
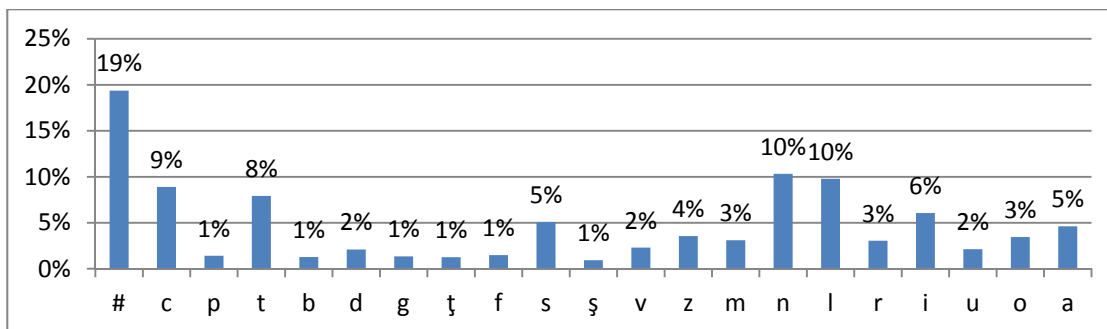
Figure 3.3.   **Contexts following Romanian /i/[29]**
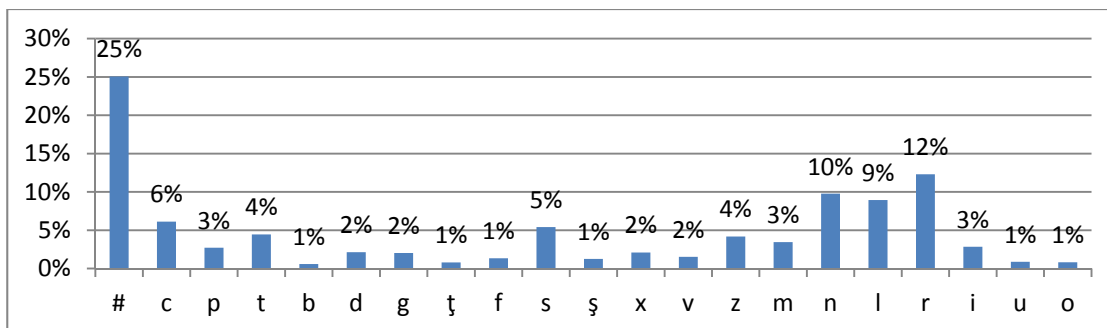
Figure 3.4.   **Contexts following Romanian /e/**
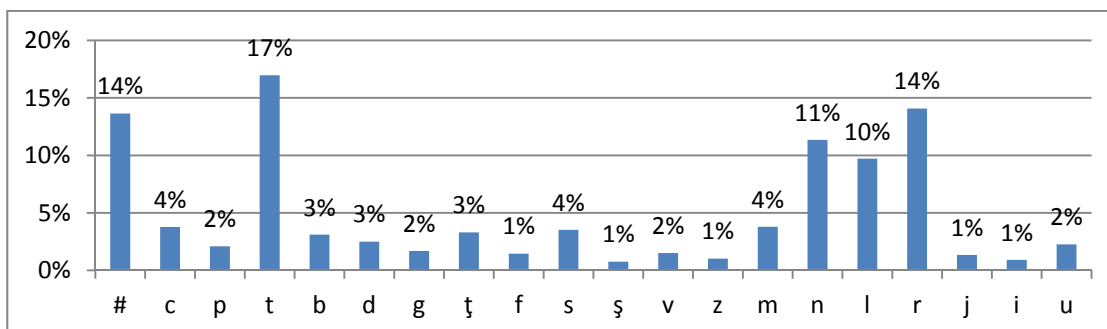
Figure 3.5.   **Contexts following Romanian /a/**

---

[29] In Figures 3-8, all segments that followed the vowel in less than 1% of cases were excluded from the graph, for illustration purposes.
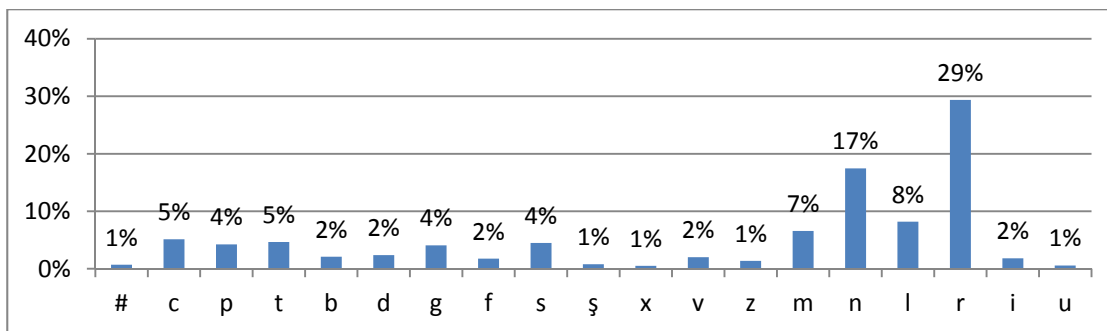
Figure 3.6.   **Contexts following Romanian /o/**
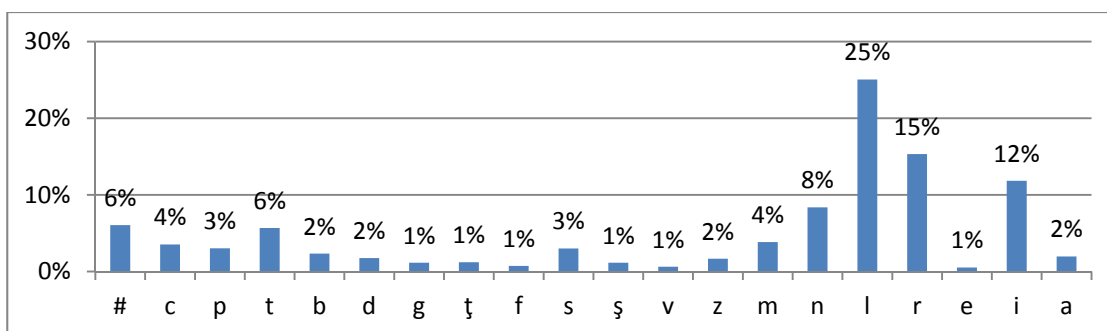
Figure 3.7.   **Contexts following Romanian /u/**
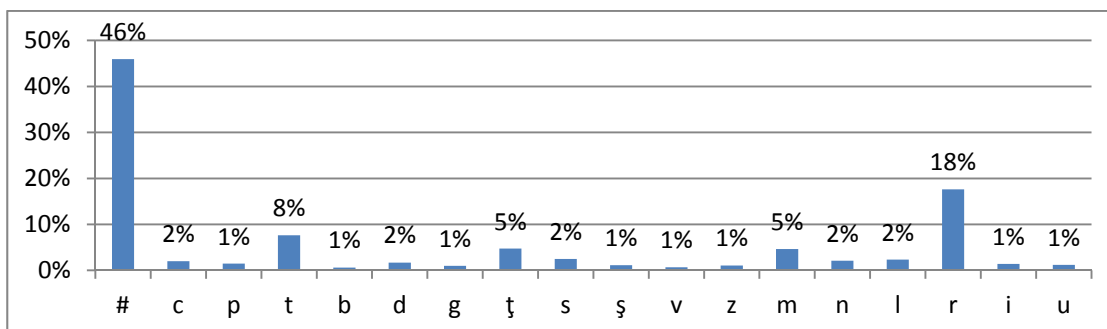
Figure 3.8.   **Contexts following Romanian /ʌ/**

In Figures 3.3-3.8, we see the distributions of contexts following six of Romanian's seven vowels. These distributions are clearly not uniform. One striking fact is that the three most common vowels, /i/, /e/ and /a/, have very similar profiles with regard to the contexts they precede: word boundaries, as well as /t/, /s/, and high-sonority liquids and nasals appear most frequently following these vowels. The back vowels also have similar profiles to one another: following /o/ and /u/, liquids and

86

nasals are by far the most common contexts, while these rarely occur at word boundaries. In fact for all of these vowels except /o/ and /u/, the most common following environment is a word boundary, indicating the frequency with which these vowels are word-final. (/o/ and /u/ do not appear word-finally due to their historical loss in that position.) This is especially true for /ʌ/, which falls at word boundaries 45.9% of the time. These are mostly feminine nouns and adjectives, evidence for the morphological link between vowel type and frequency. Other morphological markers at word boundaries are /i/, in masculine plurals and infinitives; /e/, in feminine plurals; and /a/, in feminine definite forms and infinitives.

High-frequency consonants often follow each vowel: /t/, /l/, /n/, and /r/. One of the most frequent following segments for /u/ (Figure 3.7) is /i/; this comes from words like *muzeului* 'of the museum,' in which –*ului* marks the genitive-dative case. Figure 3.8 shows that nearly half the instances of /ʌ/ are word-final, but other than that, no percentage in these figures reaches even 30%; and the highest percentages are all linked to the most common consonants of Romanian or to morphological facts. In other words, there is no evidence that phonological conditioning by a certain consonant affects the distribution of these vowels. The next figure (Figure 3.9), shows that these tendencies do not hold for the set of contexts that follow /ɨ/.
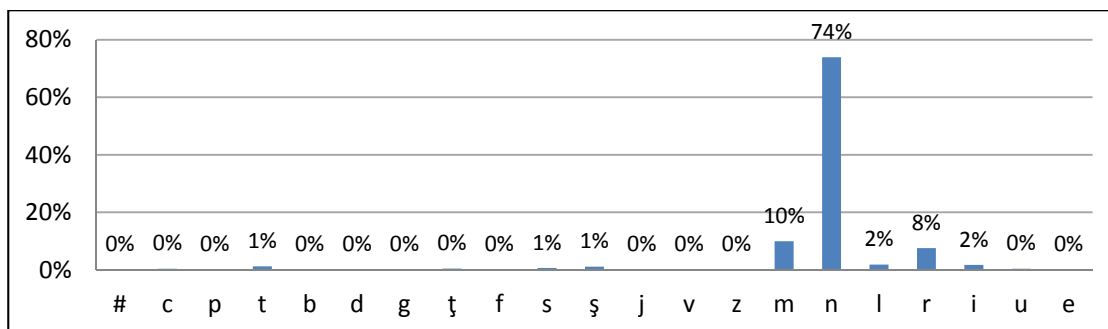
Figure 3.9.　　**Contexts following Romanian /ɨ/**

The picture in Figure 3.9 is strikingly different from the other six vowel phonemes. The vast majority of tokens of /ɨ/ – a total of 74% – precede /n/ in Romanian. Another 10% precede /m/; and 7.7% are followed by /r/. No other segment follows more than 2% of instances of /ɨ/. These three frequent following environments correspond to the phonological processes that gave rise to /ɨ/ in Romanian. This indicates that while /ɨ/ can appear in the vicinity of various consonants in Romanian, with the effect that a reliable *rule* about its distribution is not possible, there are very strong *tendencies* that help describe or predict the appearance of /ɨ/. In other words, the allophonic history of /ɨ/ has left a strong mark on the segment's distribution, and the use of /ɨ/ has not greatly expanded beyond its original conditioning environments.

To fully picture the relationship between /ɨ/ and its surrounding environment, I examine the co-occurrence of /ɨ/ and /n/ from the point of view of the latter, which is a highly frequent consonant in Romanian. Since /ɨ/ is very infrequent in the language, it might not make up a large percentage of the preceding segments for /n/; however, if the two do tend to co-occur, this is further evidence that they lie in a phonologically-conditioned relationship. I argue that this is the case based on results shown in Figure 3.10, which shows the relative frequencies of each vowel type in pre-nasal (/n/ only) position.
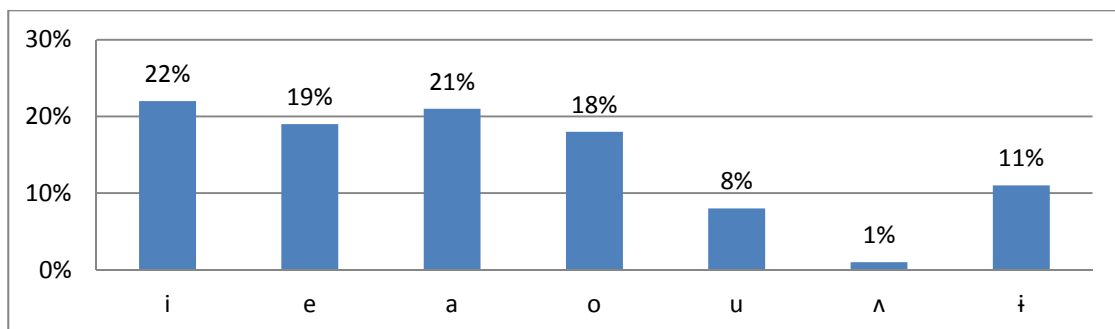
Figure 3.10.   **Vowels preceding Romanian /n/**

In Figure 3.10, /ɨ/ (shown as < â > in the figure) makes up 11% of the vowels

preceding /n/, which is much larger than /ɨ/'s frequency in the language overall (less

than 2%). Even though /i/, /a/, /e/ and /o/ have a higher rate of occurrence with /n/ than

/ɨ/ does, this can be explained by the fact that those four vowels are many times more

frequent than /ɨ/ in Romanian. Although /i/ is over 20 times more frequent than /ɨ/ in

the language overall, it is only twice as likely to occur before /n/. On the other hand,

/ʌ/ occurs very infrequently before /n/, in only 1% of cases; in that environment, /ɨ/

was phonologically favored among central vowels. To verify that the relationship of

co-occurrence between /ɨ/ and a following /n/ is higher than that between other vowels

and /n/, I compare each vowel's overall type frequency to its frequency preceding /n/.

This comparison effectively tests whether a vowel's presence before /n/ is greater than

chance: if the two frequencies are found to be equal, there is no evidence of a

particular relationship between /n/ and that vowel. Specifically, I argue that if /ɨ/ is

more frequent before /n/ than elsewhere, the evidence of an interaction between /ɨ/ and

/n/ is strengthened. This comparison uses the calculation in (3.5), where *X* is a

particular vowel and *V* represents all vowels; the results of these comparisons appear

in Figure 3.11.

(3.5) $\qquad \dfrac{Count(X)}{Count(V)} \quad \text{vs.} \quad \dfrac{Count(Xn)}{Count(Vn)}$
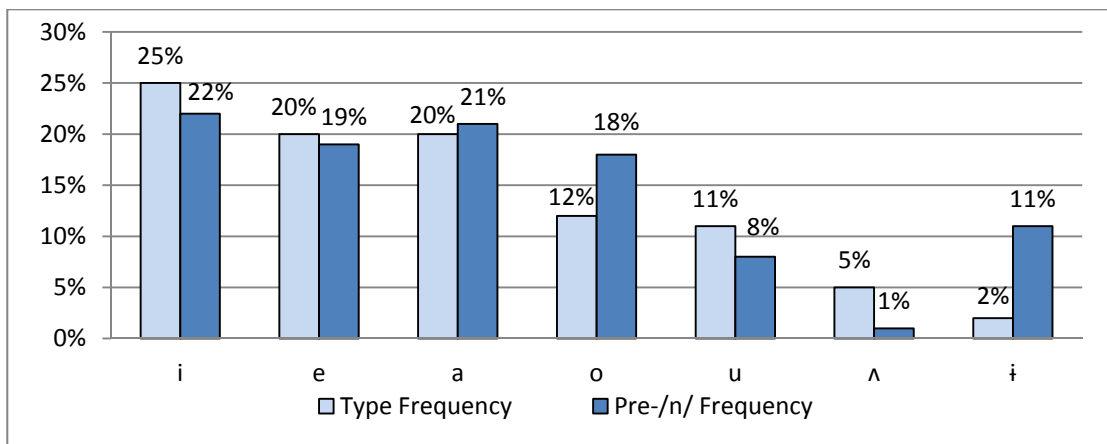
Figure 3.11.   **Type frequency vs. pre-/n/ frequency in vowels**

Figure 3.11 shows that for several Romanian vowels, a comparison of overall type frequency with type frequency before /n/ yields the result in (3.6), meaning that these vowels are less frequent before /n/ than they are overall. For /ɨ/ the opposite is true and (3.7) holds. The difference in relative frequencies is greatest in the case of /ɨ/: its overall type frequency is 2%, but before /n/ it accounts for 11% of vowels in that position. This is due to the historical conditioning relationship between these two segments. Additionally, both /o/ and /a/ are more frequent before nasals than overall (see §3.3.1 below).

$$(3.6) \qquad \frac{Count(X)}{Count(V)} > \frac{Count(Xn)}{Count(Vn)}$$

$$(3.7) \qquad \frac{Count(X)}{Count(V)} < \frac{Count(Xn)}{Count(Vn)}$$

In addition to being highly restricted to certain phonological environments, /ɨ/ has another interesting characteristic: it never appears in post-tonic position. Instead, it always appears before the main stress of a word, or is the stressed vowel. The best explanation for this phenomenon is a combination of factors. One includes the conditions of /ɨ/'s development; pre-nasal raising in particular is mostly restricted to

90

stressed syllables. The other important factor to consider is that in Romanian, many post-tonic syllables were lost through historical processes that deleted word-final vowels (after the loss of word-final consonants in Popular Latin), and syncopated unstressed syllables. The effect of these factors – phonological conditioning and historical vowel loss – highlights the differences in distribution between /ɨ/ and /ʌ/, since almost half of the time the latter appears in post-tonic word-final position. /ʌ/ appears word-finally in verbs and also in many feminine singular nouns and adjectives, while final vowel loss disproportionately affected masculine nouns and adjectives.

In summary, this section has provided a type-frequency analysis of Romanian segments within word forms. I have also provided data on the segments adjacent to each monophthongal vowel type. The vowel /ɨ/, which is very infrequent across word forms in the language, is a special case. While it is a phoneme, its distribution is highly constrained as a result of its history. The phonologically-conditioned footprint of these historical processes is in fact seen in the frequencies with which other consonants appear around /ɨ/, specifically after the vowel: nasals and /r/ make up more than 90% of the following environments for this vowel. Co-occurrences of this magnitude are not seen elsewhere in the data from the other six vowels of Romanian.

3.3. Synchronic distribution and role of /ɨ/

This section examines the synchronic distribution of /ɨ/, and considers the ways in which it does and does not match its historical conditioning environments. First, however, I revisit the question of the vowel's phonemic status through a similar case of marginal contrastiveness in English, which is a convincing comparison given the restricted distribution in which /ɨ/ remains.

The status of /ɨ/ finds a parallel in the history and modern role of /ð/ in English, which began as an allophone of /θ/. In English, [ð] originally appeared in intervocalic position, resulting from lenition of the voiceless /θ/, but its domain expanded to word-initial position in the closed set of function words *the*, *there*, *thou*, *the*, *they*, which appeared in syntactically unstressed positions, making them more susceptible to lenition (Luick 1940). When however /ð/ began to appear in syntactically stressable environments, it gained phonemic status; /ð/ and /θ/ were systematically differentiated in orthography in the 14ᵗʰ Century (Dobson 1968) and perhaps as early as the 12ᵗʰ Century, helping to date the phonemic split (Thurber 2011). Subsequent changes have obscured the environment for allophonic conditioning in many cases; for example, *bath* /bæθ/ and *bathe* /bejð/ were once /bæθ/ and /bæðian/, but the latter has reduced to /bejð/. Nevertheless, examples like this demonstrate the original intervocalic conditioning environment, just like Romanian /ɨ/ was conditioned by a following nasal or /rC/. The expansion of /ð/, like that of /ɨ/, to other environments has been minimal: in English, word-initial /ð/ appears in a limited set of function words, and in a few borrowings. The only known minimal pairs between /ð/ and /θ/ in English are *thy* /ðaj/– *thigh* /θaj/ and *either* /iðr̩/ – *ether* /iθr̩/.

Like /ɨ/ and /ʌ/ in Romanian, these two English phonemes are only minimally contrastive, and still highly phonologically conditioned. As with the contrast between English /ð/ and /θ/, that between /ɨ/ and /ʌ/ in Romanian can be described as marginally-contrastive in a pairwise fashion. These two vowels remain in a nearly-complementary distribution with one another, meaning that even if they contrast much more robustly with other members of the vowel system (as described below in §3.3.1 and §3.3.2), the functional load between these two central vowels is lower than the functional load between, for example, /ʌ/ and /a/ in word-final position, or /ɨ/ and /i/ word-initially. The mismatches in distributions between /ɨ/ and /ʌ/ appear below in

Figure 3.12, which shows the frequency with which different contexts follow each vowel.
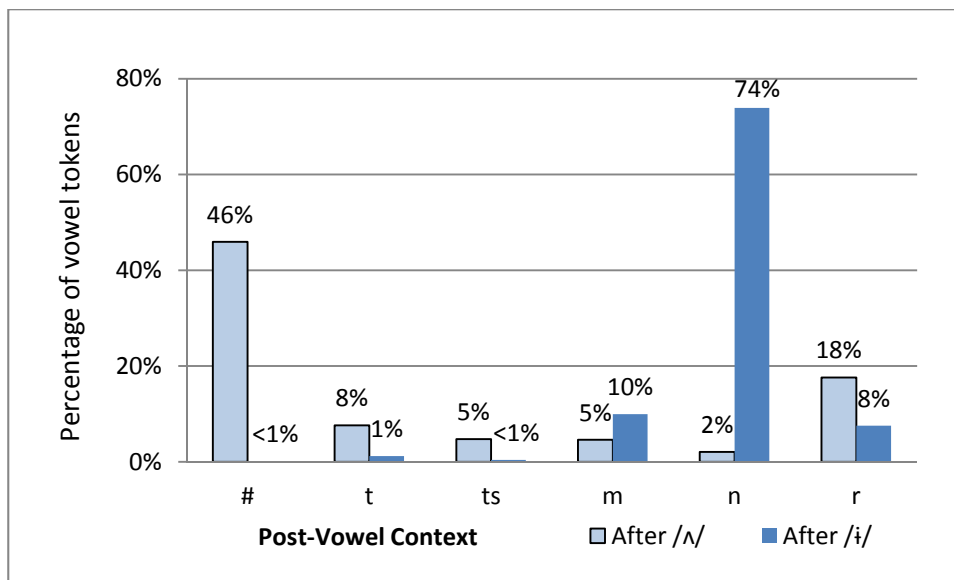
Figure 3.12.   **Contexts following central vowels**

Nearly half of /ʌ/ tokens appear before a word boundary, while nearly three-quarters of /ɨ/'s appear before an /n/. We also see mismatches in distributions in the pre-/r/ context. The tokens of /ɨ/ represented here are about 95% of all instances in the corpus, while for /ʌ/ they are about 84% of the total. This figure shows that these vowels' distributions are still quite complementary, but does not take into account the fact that /ɨ/ is always pre-tonic or stressed, while /ʌ/ is usually unstressed. That dimension is unmeasured in the present corpus, but is another factor that reduces the likelihood that the two vowels would appear in the same context.

It might seem that /ɨ/ is an insignificant, rarely-used vowel that appears in only a few Romanian words and does not participate much in the language's alternation-rich morphology. However, it is important to remember that where /ɨ/ does appear, it is often in words that have high token frequency themselves. For example, /ɨ/ occurs in

the preposition *în* 'in,' and various personal pronouns as well as in gerund forms, and in a subset of infinitives. The next subsections delve deeper into the environments in which /ɨ/ appears, and where it does or does not contrast with other vowels.

3.3.1. Non-minimal contrasts: Evidence from frequency

Chapter 2 showed evidence from minimal pairs that /ɨ/ is indeed a phoneme in modern Romanian. More evidence of this appears in Figure 3.9: each segment listed on that graph is one that follows /ɨ/ in at least one lexical item. The presence of a wide range of segments in a (post-vocalic) position from which /ɨ/ was historically conditioned demonstrates that rules about the distribution of /ɨ/ are not possible. However, Figure 3.9 also shows that to a much greater degree than for any other vowel, the distribution of /ɨ/ remains very restricted. Taken together, these two lines of evidence point toward marginal contrastiveness. In this subsection, I consider other evidence regarding the distribution of /ɨ/, beginning with words in which /ɨ/ might be expected, but instead another vowel occurs; while these data do not provide minimal pairs, they show that Romanian phonology does not *require* /ɨ/ in certain environments.

Examining the modern Romanian lexicon, we find words that have a potential conditioning environment for /ɨ/ but contain a different vowel, such as /a/ or /ʌ/ before a nasal or /r/. A large class of verbs begins with /#ɨN/ where we might expect /#ɨN/. I argue that many of these cases come from modern additions to the lexicon, giving evidence of two things: first, that the phonological processes leading to /ɨ/ are no longer active; and second, that even though /ɨ/ is predictably conditioned in many words, it *is* a phoneme, since it is not the only vowel that can appear in environments where it was allophonically conditioned.

Figures 3.3-3.9 showed the frequency with which each vowel appears before other Romanian segments. Note that 11% of instances of /a/ appear before a nasal, and 14% before an /r/. Likewise, 28% of /o/'s appear before /r/, and 18% of /ʌ/'s before an /r/. This is somewhat surprising, since I showed in Chapter 2 that a following /r/ or /n/ is a conditioning environment for /ɨ/, and gave examples in which each of the aforementioned vowels emerged in modern Romanian as /ɨ/. If there are cases in which /ɨ/ did not emerge, what kinds of words are those? I address this question below.

We often find /an/ in unstressed position, an environment where we expect to see /ɨn/ less often (due to the lack of stress); but many words with /an/ are modern additions to the lexicon, in which case /an/ can be stressed but is not conditioned to /ɨ/. These include adjectives of nationality, such as *mexican* 'Mexican' and *mozambican* 'Mozambiquan,' for countries that did not exist until after /ɨ/ became a phoneme. Other words begin with *an*, such as *anabaptist* 'Anabaptist,' *anafor* 'anaphor,' *analog* 'analog' and *anarhic* 'anarchic'; these are words for modern concepts. Some others are *–ant* words, such as *emoţionant* 'moving,' *fascinant* 'fascinating,' *pasionantă* 'passionate.' These resemble their Romance cognates, seen in French, Spanish and Italian, and it is likely that these words were adopted in the 17th Century or later, after Romanians began to have contact with speakers of other Romance languages. Thus these words were adapted to Romanian phonology *after* /ɨ/ had attained phonological status. It is likely that the educated speakers who brought new Romance cognates into the language actively differentiated between /ɨ/ and /a/ before a nasal, and recognized that /an/ was closer than /ɨn/ to the Romance pronunciation and the historical form.

Many words with the sequence /ar/ are abstract nouns, formed with the "long infinitive" of verbs in the first conjugation. A long infinitive contains the *–re* lost from Romanian infinitives; for example, *a comunica* 'to communicate' vs *comunicare* 'communication.' Another set of words with /ar/ belong to the class of '-ary'

adjectives common across the Romance languages. In Romanian, we find *extrajudiciar* 'extrajudiciary' and *financiar* 'financial.'

Many words containing /ʌr/ result from the forces of vowel harmony. In Romanian, word-final front vowels – particularly /i/ – have two possible effects on vowels earlier in the word: they can trigger stressed vowel alternations, such as in *noapte – nopți* [nǫapte – noptsʲ] 'night – nights,' *măr – mere* [mʌr – mere] 'apple – apples,' or *carte – cărți* [karte – kʌrtsʲ] 'book – books.' This last effect, a height-based alternation between /a/ and /ʌ/, produces many instances of /ʌr/ in Romanian, such as the following: *asasinări* 'assassinations'; *citări* 'citations'; *clarificări* 'clarifications.' Many of these forms belong to paradigms that contain /ar/ in the singular, and are derived from the abstract nouns mentioned above.

3.3.2. The occurrence of /ɨ/ vs /i/ in word-initial position

Another piece of evidence for the general contrastiveness of /ɨ/ comes from its presence in word-initial position. In a modern dictionary of Romanian we find, in addition to words beginning with /ɨN/, many words beginning with the prefix /in/, in which backing has not occurred. These words demonstrate a robust contrast between /ɨ/ and /i/ in word-initial position, and indicate that backing is not as active as it once was, if it still occurs.

In modern Romanian, all word-initial instances of /ɨ/ are followed by a nasal, and many have the form /#ɨN + root/, indicating prefixation. While many words beginning with /i/ have the similar form /#iN + root/, there are non-prefixed native words with initial /i/, such as *igrasie* 'dampness' and *inel* 'ring.' The words in which /#ɨN/ prefixes a verb are relatively older than the words with /#iN/. The evidence for this comes from a comparison of the roots following the prefix: words beginning with /#ɨN/ precede roots that have undergone phonological changes characteristic of native

96

Romanian vocabulary, while the roots following /#iN/ have not. For example: *însângerat* /insɨndʒerat/ 'bloodstained,' or *înmormânta* /ɨnmormɨnta/ 'bury' have undergone vocalic changes elsewhere in the word, such as the introduction of /ɨ/.

Another example of an old word is *înger* /ɨndʒer/ 'angel,' from Latin **angelu*, in which /l/ has changed to /r/ in the Romanian process of intervocalic rhotacism (Alkire & Rosen 2010). Words like *înnopta* 'put up for the night' are examples of the 'Labial Conspiracy' (Alkire & Rosen 2010), in which Latin /kt/ (from **nocte*) emerges in Romanian as /pt/. These changes began early in the history of Romanian, long before /ɨ/ split from /ʌ/, and suggest that words beginning with /#iN/ are also old. However, words with the prefix /#iN/ are not sufficient to prove the prefix's antiquity, since an old root could at any time be modified with a productive prefix.

The words with initial /iN/, on the other hand, have not gone through many historical changes, and are more recent borrowings from French or other Romance languages; or they may be *cultismos* – Latin terms which have been recently and minimally adapted to Romanian phonology. Examples include: *infractor* 'delinquent,' *ingredient* 'ingredient,' *inofensiv* 'inoffensive,' *improviza* 'improvise,' *inevitabil* 'inevitable.' These last three examples have not undergone Romanian's /b/ - /w/ merger, in which the original contrast survives in original position only, seen in Romanian *bine* 'well' vs. *vin* 'wine' (Alkire & Rosen 2010). The result of the merger is that /b/ and /w/ delete in intervocalic position (i.e. Romanian *ou* 'egg' from Latin *ovu*), and changes to /b/ postconsonantally (as in Romanian *pulbere* 'dust,' from Latin *pulvere*). The words *inofensiv, improviza* and *inevitabil* have the environment for /b/ − /w/ deletion, but it does not occur; this is evidence that they are recent loans. In *insalubru* 'unwholesome' and *insolent* 'insolent,' there is no rhotacism; and in *infractor*, *imperfect* 'imperfect' and *incorect* 'incorrect,' there is no change of /kt/ to /pt/, as would be expected in an older, native form.

This phenomenon can be explained with the help of a comparison. In English we find borrowings from French, among them pairs of words like *Charles* [tʃarlz] and *Charlotte* [ʃarlɪt], which are now pronounced [ʃaʁl] and [ʃaʁlʌt] in French. Why are the word-initial onsets different in English? In Old French, /k/ became /tʃ/ before /a/ – and while this process was active English borrowed the name *Charles*, and other words that have <ch> ~ [tʃ], like *chapel*, *chimney* and *charge*. Later, however, the affricate /tʃ/ in French reduced to /ʃ/, and only then did English acquire *Charles'* feminine counterpart, *Charlotte*, as well as *champagne*, *chevron* and *chateau* (Alkire & Rosen 2010). Thus, this split in pronunciation among the English words represents two layers of borrowing, between which the donor language underwent a phonological change. Similarly, words with /#iN/ in Romanian show the work of native processes; but the language later acquired new words, which are etymologically linked to Latin just like the native vocabulary, yet show a more recent treatment of /#iN/ sequences.

This lack of adaptation to Romanian native phonology indicates that the words beginning with /iN/ belong not to the native vocabulary of Romanian that has been in use since the 3rd Century, but rather to a layer of modern borrowings from Latin and other Romance languages. That process probably began in the 18th Century: until the 17th Century, Romanians were unaware of their link to Latin via the Roman Empire (Boia 2001). In the 18th Century, a new layer of literary language was imported (Rosetti 1973a), as Romanian intellectuals within the Transylvanian School began to claim their Roman heritage. Some dictionaries were printed with etymological spellings (for example, *terra* for *țară* /tsarʌ/ 'earth'), although these were soon abandoned in favor of a more transparent, "phonetic" spelling system. During this era, many near-Latin forms were introduced into the language. The Romanians looked to France as a model of culture for many years (Boia 2001), an interaction that left a distinct imprint on Romanian literary language.

The considerable *lack* of adaptations in new borrowings is an indicator that, not long after /ɨ/ became a phoneme, the productivity of rules that generated it began to slow. The result of this slowing is that the role of /ɨ/ is restricted to relatively old words; and morphologically, it is restricted to subsets of gerunds, pronouns, infinitives and onomatopoeias (see Chapter 2). Apart from these few productive environments and in borrowings, the presence of /ɨ/ in Romanian is an artifact of the phonological past. Nonetheless, the notable presence of vowels other than /ɨ/ in consonantal environments known to condition /ɨ/ is evidence for its phonemic status. Since we cannot predict where /ɨ/ will occur, we must conclude that it is specified underlyingly.

3.3.3. Interim conclusions: /ɨ/

As shown in Chapter 2, the role of /ɨ/ increased in Romanian throughout the phoneme's development. This chapter demonstrates that its use did not expand very far beyond its original phonological environments, such as in pre-nasal position, following /r/, or before an /rC/ sequence. In addition, words that were reborrowed from Latin and other Romance languages do not contain /ɨ/ in the phonological environments where it had earlier emerged; this indicates that as little as two centuries after /ɨ/ became a phoneme, the processes that created it became less productive. While /ɨ/ is infrequent across wordforms and has a minimal role in the morphology, it appears in some high-frequency words, such as prepositions and personal pronouns. The result of these events is seen by comparing the frequencies of different vowel types to one another. Together, /i/, /e/, /a/, /o/ and /u/ make up over 90% of vowels in a list of modern Romanian wordforms, while 5% is accounted for by /ʌ/, and /ɨ/ appears in less than 2% of wordforms. In the synchronic distribution of /ɨ/, we see little more than the phonological footprint of the vowel's development.

99

One other issue bears mention before concluding this discussion of /ɨ/'s marginally contrastive properties: the possible differences between its type frequency, quantified here, and the results that would be obtained from a token frequency corpus. A study of phoneme type frequency, under ideal conditions, quantifies the relative frequency of phonemes across the lexicon of a language by surveying its lexemes (including fixed multi-word phrases and frequent collocations), but not all possible morphological forms. This type of measurement shows how phonemes are distributed across the lexicon, and the statistical effects of type frequency, particularly that of phoneme sequences, influence adults' parsing of the speech stream and perception of phoneme identity (Pierrehumbert 2003a; Hay, Pierrehumbert & Beckman 2003).

A token frequency corpus, by contrast, allows us to measure the relative frequency with which a given type appears across a certain corpus; for example, the Brown corpus of English (Francis & Kucera 1967) contains one million words collected from 500 texts including newspapers, novels, academic journals and other sources. Calculating token frequency allows us to estimate how often speakers and hearers encounter a particular type while using a language. While it is unclear what kind of frequency is most relevant for describing phonemic status, it is important to compare the two types in order to understand how they influence various linguistic questions.

Although Romanian phonemes such as /ɨ/ and /ʌ/ appear rarely across the lexicon, I predict higher rates of relative token frequency for them. For /ɨ/, the source of token frequency is the vowel's use in common function words such as pronouns and the preposition /ɨn/ 'in', while /ʌ/ appears as a final desinence vowel in feminine singular forms and verbs. A token frequency corpus is not presently available for Romanian, but a future comparison of type and token frequency results would give greater insight into speakers' daily use of Romanian, and additionally would allow us

to pinpoint the relative importance of type vs. token frequency effects in speech production and perception.

In the next subsection, I analyze the other two marginally-contrastive vowels of Romanian, /e̯a/ and /o̯a/. As shown above in §3.2.2, these also have very low type frequency; however, as I will describe, they have a significant presence in morphological endings, and thus I also predict relatively higher token frequency for them.

3.4.   The frequency and distribution of /e̯a/ and /o̯a/ in Romanian

Having considered both the development and synchronic distribution of /ɨ/ in Romanian, I now turn to a corpus-based analysis of the language's diphthongs /e̯a/ and /o̯a/. The history and development of these vowels has several characteristics in common with that of /ɨ/: they originally appeared through phonological conditioning in native words, and are now phonemic, as demonstrated by (near-) minimal pairs. Influxes of borrowings in each case helped cement this status, but each vowel's distribution remains restricted, and its type frequency remains very low compared to other vowels, although they are hypothesized to have high token frequency. However, there are important differences in the distributions of /ɨ/ vs. the diphthongs. While the defining characteristic of /ɨ/ as marginally contrastive is its continued restriction to a small set of phonological environments, the diphthongs instead can be described by their presence in certain *morphological* environments. In this section, I examine the role of /e̯a/ and /o̯a/ in Romanian morphophonology, and argue that based on their history and distribution in the lexicon, these diphthongs add to the inventory of marginally contrastive vowels in Romanian. While /ɨ/ has a small role in Romanian morphology and is hypothesized to have been used as a marker of loanwords (Schulte 2005), the diphthongs appear frequently throughout the morphology of Romanian, to

101

the extent that Chiţoran (2002) appeals to an interaction between morphology and phonology to explain their distribution in an Optimality Theory (OT) framework.

Classical cases of morphologization are those in which an alternation that is originally phonetically natural realigns to be associated with a particular morphological context (Hyman 1975). An example is Umlaut in German, in which historically a final plural-marking /i/ triggered fronting and raising of preceding /a/ to /ɛ/. Synchronically this process can only be described by referencing the morphological context (e.g., +plural). This is *not* the case in Romanian: where the diphthongs are concerned, the phonetic environment that historically triggered their alternation with monophthongs is still active (for example, [se̯arʌ] vs. [serʲ], 'evening(s)'). But the diphthongs themselves – /e̯a/ in particular – have also extended into new environments, such as word-final unstressed position. In that context [e̯a] occurs without a conditioning environment – not because the environment was once present and has been lost, as in German Umlaut, but because the diphthong was never conditioned in that context. Since /e̯a/ and /o̯a/ are not morphologized in the typical sense, but are rather incorporated into larger morphological units, I refer to these as 'morphologized uses' of the diphthongs.

To explore the marginal contrastiveness of /e̯a/ and /o̯a/, I review the evidence for their phonological status, their type frequency characteristics and acoustics. I then examine each diphthong within the morphological markers of Romanian, data which demonstrate the crucial role of loanwords in developing the diphthongs' synchronic distributions. Although /e̯a/ and /o̯a/ are often treated as front- and back-vowel counterparts of one another, and undergo near-parallel phonological alternations, their distributions throughout the Romanian lexicon reflect their participation in different sets of morphological paradigms, and different languages of origin where loanwords are concerned.

102

3.4.1. Phonological status

Within Romanian phonology, /e̯a/ and /o̯a/ are traditionally regarded as alternants of /e/ and /o/; for historical accounts of their emergence, see e.g. Rosetti (1958; 1959; 1976; 1981); Vasiliu (1968); and Sala (1976). Historically the phonology prohibited these diphthongs in unstressed syllables; however, morphologically complex sequences of /e/+/a/ can create the diphthong [e̯a] in unstressed syllables. /e̯a/ alternates with /e/ when the stressed vowel slot precedes a front vowel, while /o̯a/ alternates with /o/ when it precedes a high front vowel (/i/). Additionally, /o̯a/ cannot occur in the final syllable of a prosodic word, meaning that it does not surface in monosyllabic words. Chiţoran (2002c) links this restriction to the tendency for /o̯a/ to appear in the feminine forms of adjectives, which have a final desinence vowel, and whose masculine counterparts have no final vowel, are thus monosyllabic, and contain monophthongal /o/. The alternations in which /e̯a/ participates can be accounted for by two slightly different processes of metaphony.

Chiţoran (2002c) analyzes these alternations as an interaction of vowel lowering under stress, which promotes the diphthongs, with the force of metaphony, which encourages phonological matching of height features between a suffix and the stressed vowel that precedes it. The square phonemic vowel chart proposed by Chiţoran and used elsewhere in this dissertation is reproduced in Table 3.1. By analyzing /e̯a/, /a/ and /o̯a/ as front, central and back low vowels, Chiţoran facilitates a height-based explanation of their alternations with the mid vowels /e/, /ʌ/ (or /ə/) and /o/, respectively.

Table 3.1   **Romanian Vowels**

	Front	Central	Back
High	/i/	/ɨ/	/u/
Mid	/e/	/ʌ/	/o/
Low	/e̯a/	/a/	/o̯a/

Chițoran (2002c:211) argues that /e̯a/ and /o̯a/ are not glide-vowel sequences, but that they behave as a single unit occupying one mora in the prosodic structure. While many instances of these diphthongs are phonologically regulated, others are etymological, as evidenced by near-minimal pairs in which monophthongal reduction does not occur, indicating that /e̯a/ and /o̯a/ are underlying in certain cases (Chițoran 2002c:219). Examples of minimal contrast between the diphthongs and monophthongs include /te̯amə/ 'fear' vs. /temə/ 'theme'; /se̯arə/ 'evening' vs. /serə/ 'greenhouse'; /to̯anə/ 'whim' vs. /tonə/ 'ton'; and /ko̯apsə/ 'hip' vs. /kobzə/, an old musical instrument (Chițoran 2002c:210). Chițoran (2002c:219) proposes that the historical phonological conditions which triggered /e̯a/ and /o̯a/ disproportionately targeted certain morphological classes, like verbs and adjectives, such that when these phonological rules ceased to be active, most instances of the diphthongs were reinterpreted as morphological markers. Those which could not subsequently be explained by morphology must be phonemic, and underlying rather than phonologically derived.

For a detailed review of the morphological environments in which the diphthongs are most heavily conditioned, see Chițoran (2002c:sec. 6). The present

analysis, in contrast, focuses on the consequences of this heavy morphological use for the diphthongs' frequency in Romanian, showing their distribution among different morphological endings and lexical categories as evidenced by a database of Romanian word forms. While both /e̯a/ and /o̯a/ appear in core native vocabulary – words in which these vowels were originally phonologically conditioned but may now be underlying – the presence of each was also bolstered by an influx of loanwords. As a result, /e̯a/ and /o̯a/ appear in a larger set of phonological environments, and likely have a larger presence in the language, than they would through native phonological processes alone.

3.4.2. Type frequency

As shown in §3.2.2 (Figure 3.1), the diphthongs /e̯a/ and /o̯a/ have very low type frequency in Romanian; their frequency is comparable with that of marginally-contrastive /ɨ/. The front diphthong /e̯a/ accounts for 1.78% of vowels in the corpus examined here, while /o̯a/ accounts for only 0.74% of vowels.[30] Compared with /i/ (25%), /e/ (20%) and /a/ (20%), the diphthongs fill a tiny portion of vowel slots in Romanian lexical items; all monophthongs in Romanian have higher type frequency than these two diphthongs, which appear almost exclusively in stressed syllables.

3.4.3. Acoustics of /e̯a/ and /o̯a/

As described in Chapter 4, the phonetics of /e̯a/ and /o̯a/ show that although they pattern phonologically as the low counterparts of /e/ and /o/, structurally they are diphthongs with two targets: their formant trajectories first match /e/ or /o/, followed by a steady state of /a/. This is illustrated in Figure 3.13, previewing a result from

---

[30] When we take into account the <ea> and <oa> sequences which are synchronic instances of hiatus, not diphthongs, these vowels' type frequency drops to 1.66% and 0.68%, respectively.

Chapter 4 which plots the mean F1 and F2 formant values for female Romanian speakers. In this figure, each monophthong is represented by a single point for each speaker, but /ea̯/ and /oa̯/ are shown by a measure taken and averaged during the mid-vowel portion, at the beginning of the sequence (at 10% of its total duration), and one taken at 70% of its duration, during the steady state of the /a/ portion. These data demonstrate that speakers attain both targets in the realization of these diphthongs. Furthermore, these targets are acoustically quite similar to those for the monophthongal realizations of [e], [o] and [a], lending support to the diphthongs' transcription as sequences of a mid and low vowel.
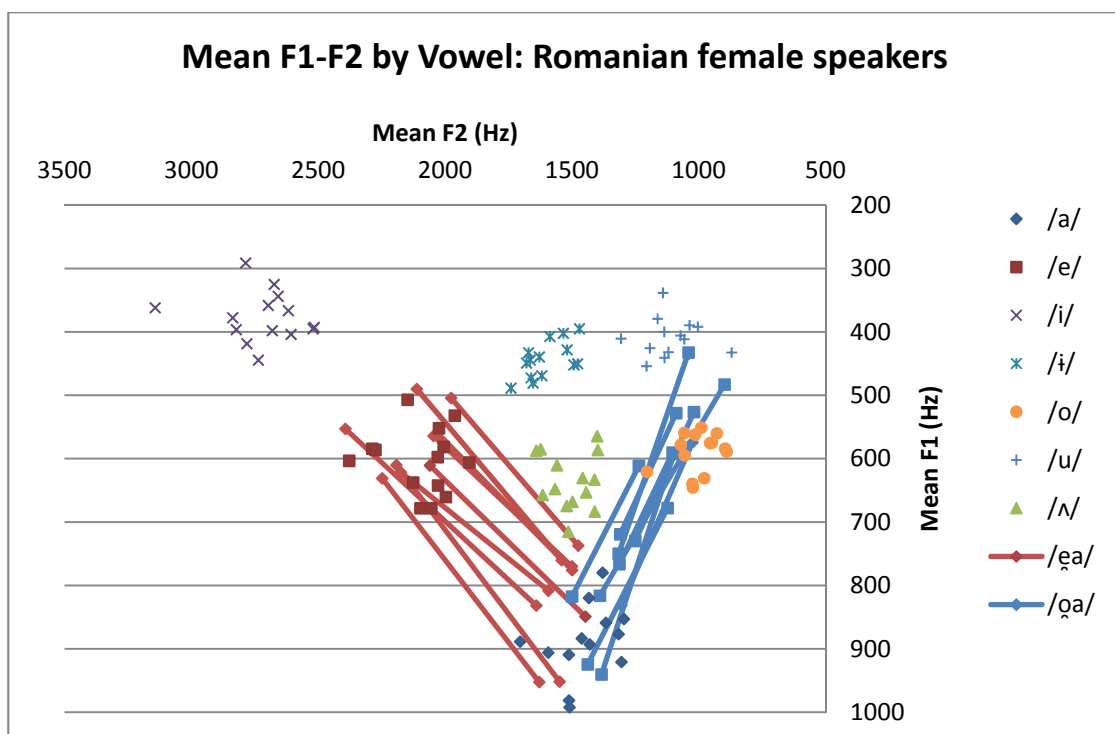
Figure 3.13.   **Mean F1 and F2 values for female speakers, for all stressed vowels (14 speakers)**

3.5.   Frequency of diphthongs by context

Having reviewed some basic phonological and phonetic characteristics of /e̯a/ and /o̯a/, I now turn to an analysis of the contexts in which they occur, based on data from the type frequency corpus of wordforms described in §3.2.1. In the preceding analysis for /ɨ/, I focused on the segments surrounding that vowel in each wordform – specifically, the following segmental environments – and I found that the originally allophonic characteristics of /ɨ/ are still reflected in these data, particularly in the fact that in over 90% of wordforms in which it appears, /ɨ/ is followed by a historical phonological trigger. I present a similar analysis for both /e̯a/ and /o̯a/ here; however, rather than examine the consonants that precede and follow these vowels, I focus on the morphological contexts in which they appear, or on their lexical stratum or etymological origin. For each diphthong, I show that a large majority of wordforms can be accounted for in terms of their use in certain morphological categories, which largely determine the phonological contexts in which the diphthongs are found. This analysis illuminates the great degree to which the diphthongs are restricted to certain morphological categories, and shows the relatively small number of core native lexical items in which their presence is not directly linked to morphology (but was likely phonologically conditioned). Finally, and with similarity to the case of /ɨ/, there is a significant presence of loanwords in these data, in which foreign sounds were adapted to Romanian phonology through use of the diphthongs.

To perform this analysis, I compiled all the wordforms that contained either /e̯a/ or /o̯a/. I then used formulas to search through the data for instances of /e̯a/ or /o̯a/ that were markers of obvious morphological categories: for example, <ea> in word-final position, which could be an infinitive, a Turkish loanword, a feminine noun with a final vowel /e/ and definite marker /a/, or a verb in the 3rd singular imperfect form. Once I had categorized as many vowels as possible using these basic classifications, I

processed the remaining words manually using an online dictionary (DEX 2011) to learn the part of speech of each, and whether it was a native or borrowed word, in order to find a morphological or phonological explanation for the presence of the diphthong. These categories are divided into two general types: Morphologized diphthongs, which appear in morphological endings and are thus predictable to a certain degree; and diphthongs in lexical items, which are not linked to a specific function and thus are less predictable (although they appear in restricted phonological environments). The specifics of the analysis and results for each diphthong appear in the following subsections.

3.5.1. Frequency of /e̯a/ by context

To examine the frequency of the diphthong /e̯a/ in various phonological and morphological contexts, I first used an automated search to categorize as much data as possible, after which I categorized the remaining wordforms by hand. Out of the word list containing more than 88,000 word forms (see §3.2.1 for details), I found 6,327 instances of the sequence <ea>. Of these, 613 are excluded from further analysis because they are instances of hiatus /e.a/; 41 more were unidentifiable by search and are also excluded. Of the remaining 5,673 tokens, 5191 (91.5%) are morphologized diphthongs; 482 (8.5%) are part of a lexical item or content word. In fact, morphologized instances of /e̯a/ are further dividable into phonological diphthongs that have a morphological use, and sequences of root-final /e/ plus a morphological ending /a/ which are realized as diphthongs (described below). I first show how the morphologized diphthongs are distributed among morphological endings in Romanian, in Figure 3.14; the results for diphthongs in lexical items follow in Figure 3.15. An explanation of the categories into which the diphthongs fall follows each figure.

3.5.1.1. Morphologized /e̯a/

The data in Figure 3.14 show that more than half of instances of morphologized /e̯a/ in the corpus appear in word-final position (shown in the "definite /e̯a/" entries). This category includes instances in which the sequence <ea> is formed not by a phonological diphthong, but by the addition of the definite article /a/ to a root ending in /e/; although these are morphologically complex sequences, they are realized as diphthongs (Stefania Marin, p.c.). The next most common category includes verbs, which subsumes several conjugated forms. Explanations of each category follow.
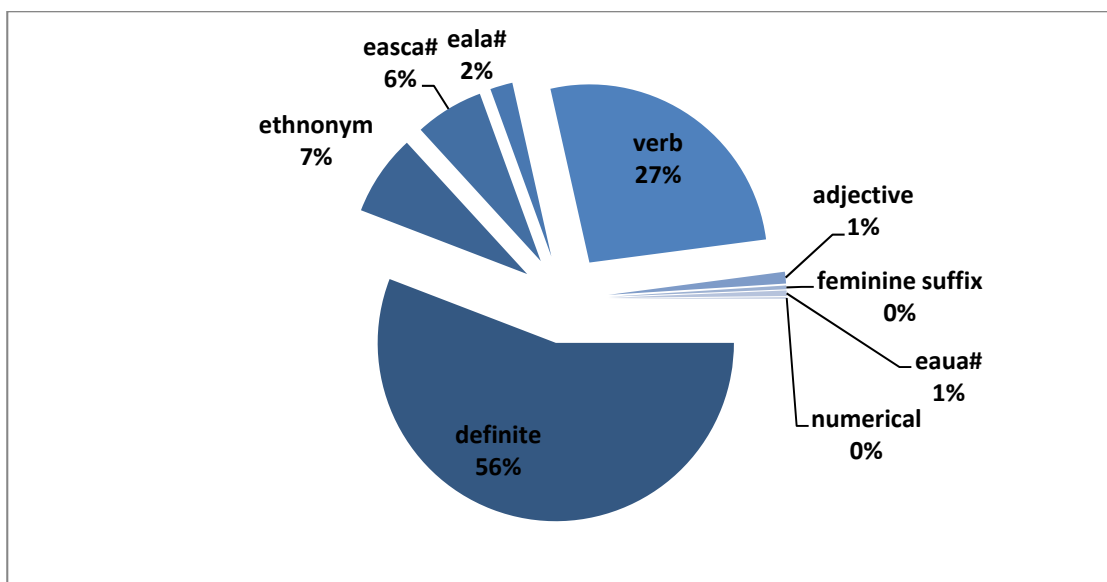
Figure 3.14.   **Frequency of Romanian diphthongs: Morphologized /e̯a/**

definite /e̯a/ (2899 word forms): This category includes words whose final sequence <ea> represents the addition of a definite suffix /a/ to a root-final /e/; these are not phonological diphthongs, although they are phonetically realized as such,[31] which justifies their treatment as diphthongs in this analysis. Many of these end in either

---

[31] This was confirmed by independently querying 5 native speakers, all of whom had the same intuitions about the monosyllabic status of these sequences; two were linguists, and both concurred that these sequences are realized as diphthongs.

<area#>, and are nominalized definite infinitives; <tatea#>, which have the "-*ity*"

suffix plus a definite article; and <iunea#>, as in *pasiunea* 'passion (def.)'.

verb (1373 word forms): This category includes several smaller categories of words

in which either the morphological marking unambiguously shows that the wordform is

a verb, or a manual search showed that the word was a verb. It includes the following:

ează#: Words ending in <ează>, which are verbs that use the stem extender

<ez>, such as *fumează* 'he smokes'.

Imperfect verbs: Words ending in <eau>, the 3rd plural imperfect ending;

<eam>, the 1st singular/plural imperfect ending; or <eai>, the 2nd singular imperfect

ending. Note that the final case is one in which <ea> may precede /i/, which is

otherwise phonologically forbidden; this may be an instance of morphological

regularity overriding phonological constraints on word shape.

Other verbs found through a manual dictionary search include forms like

credeaţi 'you (pl.) believed (imp.)'.

ethnonym (382 word forms): This category includes several smaller categories of

words in which either the morphological marking unambiguously shows that the

wordform is an ethnonym, or a manual search showed that the word was an ethnonym.

It includes the following: <ean#>; <eană#>; <eanul#>; <eanu#>; <eancă#>;

<eanca#>, all of which are based around the ending <ean>, which indicates an

adjective of nationality. Other ethnonyms found through a manual dictionary search

include forms like *turceasca* [turtʃ̦easka] 'Turkish'.

easca# (382 word forms): This category includes both feminine adjectives ending in <easca> or <ească>, and verbs ending in <ească>, which are generally 3rd person subjunctive forms; for example, *cosească* 'mow' (3 subj.), *păstorească* 'pastoral'.

eala# (106 word forms): This category includes feminine adjectives ending in <eală#> or <eala#>. Examples are *beteală* 'tinsel' and *cheală* 'bald'.

adjective (55 word forms): This category includes words which a dictionary search showed to be adjectives, and were not captured in the more general searches for typical adjective forms. An example is *ştearsă* 'deleted, dull (f. sg.)'.

feminine suffix (18 word forms): These are words with feminine suffixes <eaţă>, such as *verdeaţă* 'greenness,' or <easa>, as in *baroneasa* 'the baroness.'

eaua# (26 word forms): These words end in <eaua> ['e̯a.wa], and are nouns ending in stressed –*ea* which are marked as definite, i.e. *cafeaua* [ka.'fe̯a.wa] 'the coffee.'

numerical (9 word forms): Ordinal numbers may end in /e̯a/ in Romanian. Examples include *cincea* 'fifth (fem.)', *cincizecea* 'fiftieth (fem.)'.

3.5.1.2.   Lexical items containing /e̯a/

The data in Figure 3.15 show the categories into which the lexical items where /e̯a/ is found fall. This division shows how many of these lexical items are native to Romanian and how many were borrowed, which is an indicator of the lexical strata in which /e̯a/ developed. The fact that nearly half these words are loans or cultismos, for example, indicates that /e̯a/ is not restricted to native words.
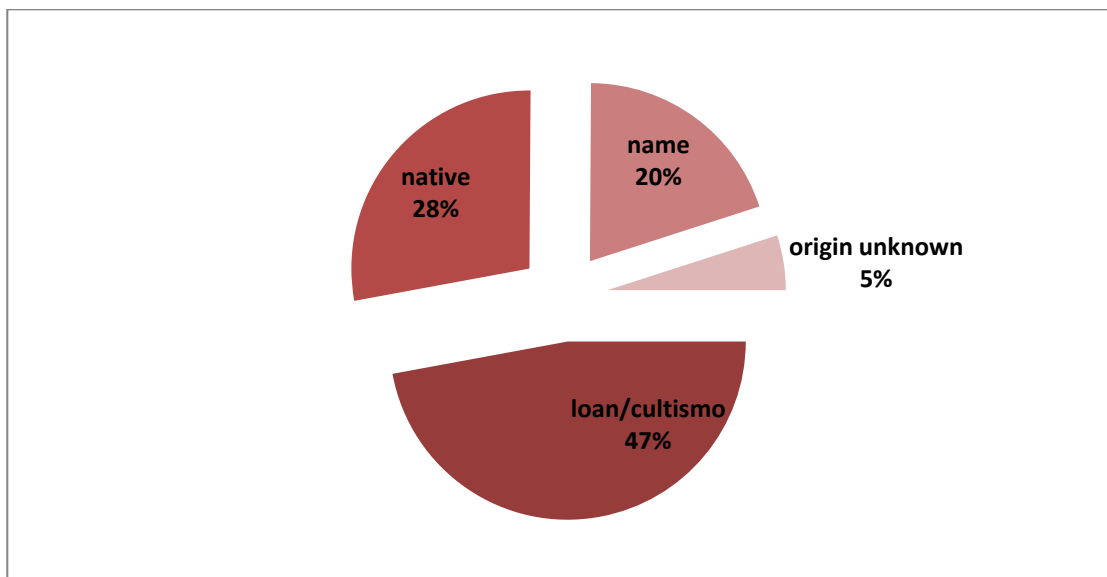
Figure 3.15.   **Frequency of Romanian diphthongs: Lexical items containing /e̯a/**

loan/cultismo (227 word forms): This category includes words that the dictionary lists as loans, or are clearly 'cultismos', words usually of Romance origin that have been recently adapted to Romanian with minimal phonological changes (Alkire & Rosen 2010). Examples include *teatru* 'theater' from French *théâtre* and *dovleac* 'pumpkin' from Turkish *devlek*.

native (135 word forms): This category includes words in which /e̯a/ appears within the root of a native Romanian word (i.e. not within a morphological ending) or as a result of vowel lowering under stress, a native phonological process. Examples include *beat* 'drunk'; *gheaţă* 'ice'; *ardeal* 'Transylvania.'

name (96 word forms): These include words with the sequence <ea> which are proper names, such as *Viteazu*, a Romanian surname.

112

unknown origin (24 word forms): These words appear in the online dictionary, but their origin is unknown; an example is *fleac* 'a job of little importance.'

This compilation of the data demonstrates that 91.5% of all the wordforms containing /ęa/ can be accounted for in terms of their role within a morphological ending, mainly including words with final <ea#>; verbs; adjectives and verbs ending in <ească#>; <eală#>; <eauă#> and ethnonyms. This means that the appearance of /ęa/ is often predictable: with the surrounding morpho-syntactic context, a listener may be primed to expect /ęa/ in an utterance, for example one discussing actions in the past (imperfect verbs) or with a feminine subject. Additionally, this result parallels what has been demonstrated for /ɨ/: once the regular, predictable tokens of the vowel have been accounted for, few unpredictable and necessarily underlying tokens remain. In this list, the "unpredictable" instances of /ęa/ include loans, native words, names, and words of unknown origin. Only in these most unpredictable contexts that one can solidly argue that this diphthong is contrastive; based on the data presented here, and given its overall low type frequency, /ęa/ appears to be only marginally contrastive. By that I mean that its distribution is nearly predictable based on morphological context, and that less than 500 wordforms out of 88,000 within the corpus form the basis of its contrastiveness with other lexical items.

3.5.2. Frequency of /ǫa/ by context

To analyze the contexts in which /ǫa/ appears, I used the same technique described above in §3.5.1 to perform various automated searches on the list of wordforms containing /ǫa/, before turning to manual searches using the online dictionary. Given the lower type frequency of /ǫa/ relative to /ęa/, it is not surprising that the corpus contained many fewer instances of the back diphthong: out of 2,609

words, 189 were rejected as instances of hiatus[32] (/o.a/), and 16 other forms were excluded because they could not be found in a dictionary search. Of the remaining 2,405 instances of /o̯a/, 1,761 (73.3%) are morphologized diphthongs, meaning they appear in a morphological ending; and the remaining 643 (26.7%) are diphthongs in lexical items, which do not have a morphological function and are thus not predictable by morpho-syntactic context. Figure 3.16 shows how /o̯a/ is used across morphological endings in Romanian, while Figure 3.17 shows its use in lexical roots. Explanations of the categories used follow each figure.

3.5.2.1.   Morphologized /o̯a/

As for the morphologized instances of /e̯a/, a single morphological category dominates among tokens of morphologized /o̯a/. Since /o̯a/ is restricted from word-final syllables, its morphological presence tends to be in penultimate syllables, where a following /a/ or /e/ conditions it. The morphological categories in which this occurs (Figure 3.16) are explained below.

---

[32] This category includes words in which the sequence <oa> represents the phonological sequence /o.a/, not the diphthong /o̯a/. These words were generally formed through compounding (of separate lexical forms, or of a prefix or suffix plus a root), such as *retroactiv* 'retroactive'; or they may be Romance loans adapted to Romanian phonology, such as *toaletă* 'toilet.'
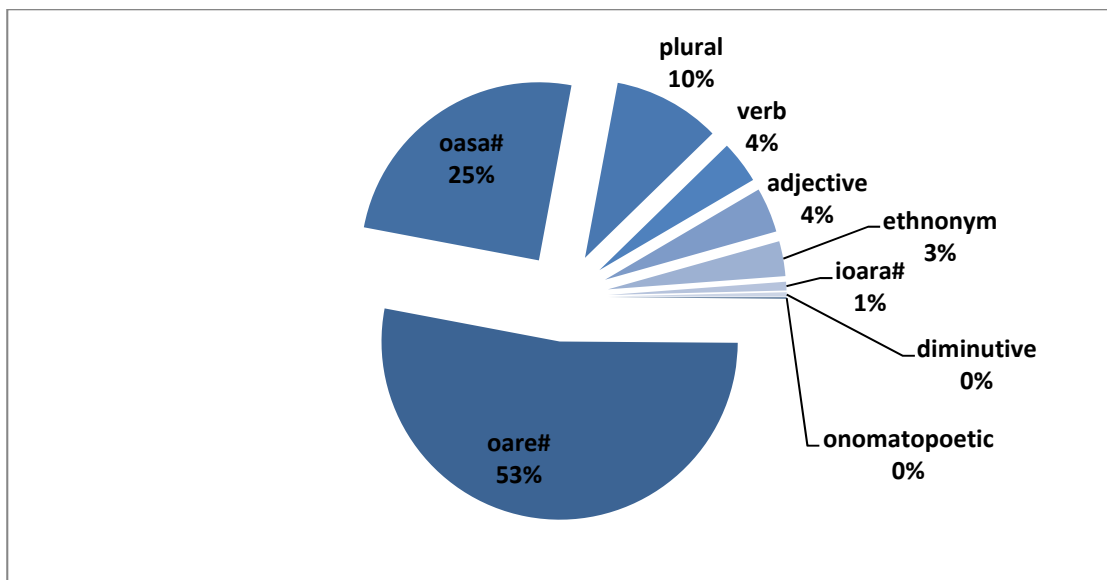
Figure 3.16.   **Frequency of Romanian diphthongs: Morphologized /o̯a/**

oare# (932 word forms): The suffix –*oare* marks feminine words; it is the feminine counterpart of –*or*. The data in this category have one of the following endings, each of which constitutes a different case marking: <oare#>; <oarele#>; <oarelor#>; <oarea#>; <oarei#>. Examples include *aviatoare* 'aviator' and *fecioară* 'virgin'.

oasa# (440 word forms): The suffix <oasa#> appears in feminine forms, such as *voluminoasă* 'voluminous.' The formula used to find these wordforms searched for the following word-final sequences: <oasa#>, <oasă#>, <oase#>.

plural *oane#* (172 word forms): When the sequence –*oane* appears word-finally, it unambiguously marks a feminine plural; many of these are neuter nouns, which are masculine in the singular (ending in –*on*) and feminine in the plural (ending in –*oane*). In that case, /o̯a/ is part of a morphological marker of number; examples of this are *eşaloane* 'echelons' or *sifoane* 'siphons.' Also included in this calculation are plural definite and genitive forms, e.g. *milioanele* 'millions (def.)' and *milioanelor* 'millions

115

(gen.)' Many words in this paradigm, including these examples, are loans from French. Note that the ending *–oane* does not always correspond to singular *–on*; when the singular is *–oană*, the diphthong does not serve a morphological function. Those words are categorized below with the diphthongs in lexical items.

verb (68 word forms) Fewer verb paradigms use /o̯a/ than use /e̯a/, and the relevant morphology is often ambiguous, but /o̯a/ does mark the third person in some verb conjugations; these include *coboare* 'descend (3 sg./pl.)', *zboare* 'fly (3sg./pl.)'.

adjective (72 word forms): This category includes words which a dictionary search showed to be feminine adjectives; examples include *trăitoare* 'living' and *anterioară* 'anterior.' Of these adjectives, 26 were direct adaptations of a French equivalent. A handful of adjectives, such as *pavoazate* [pa.vo̯a.'za.te] 'decorated with flags' contain an unstressed /o̯a/.

ethnonym (56 word forms): The diphthong /o̯a/ is used in suffixes which unambiguously mark ethnonymic adjectives; the words in this category have one of the following endings, each of which represents a different case marking: <oaica#>, <oaică#>, <oaice#>, <oaicei#>, <oaicelor#>, <oaicele#>. Examples include *chinezoaică* 'Chinese'; *englezoaică* 'English.'

ioara# (14 word forms): The suffix <ioară> is an indicator of feminine nouns; for example, *mioară* 'ewe.'

diminutive (7 word forms): The diphthong /o̯a/ may appear in diminutive suffixes, as in *aripioară* (*aripă* 'wing', dim.), 'flipper (of an animal), landing flap (of a plane).'

3.5.2.2. Lexical items containing /o̯a/

The data in Figure 3.17 show the categories of lexical items in which /o̯a/ appears; the three main contributors are native words, nativized loans, and loans and cultismos. These and the remaining categories are explained below.
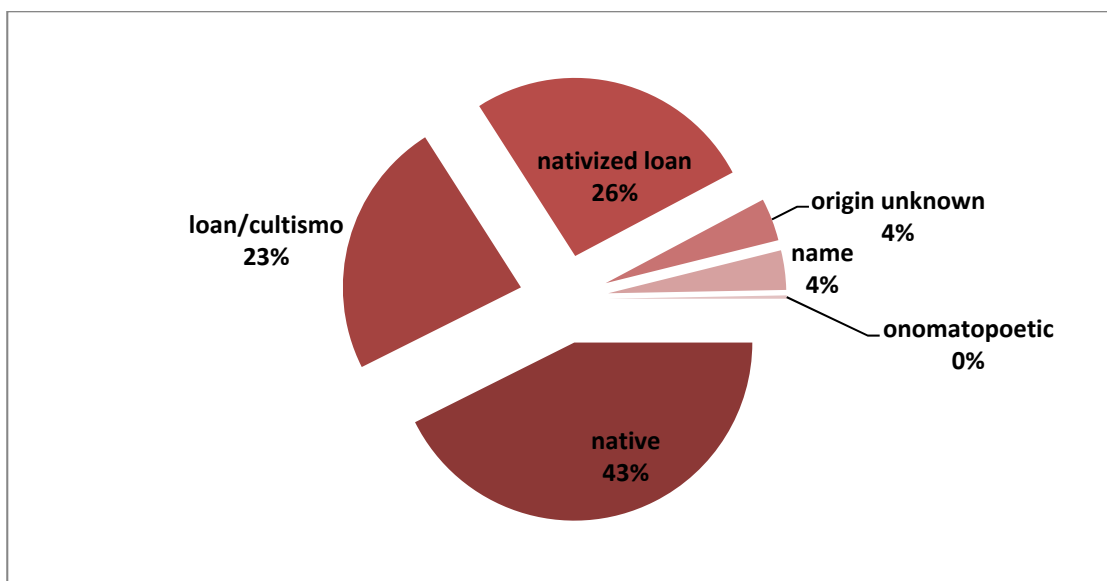
Figure 3.17. **Frequency of Romanian diphthongs: Lexical items containing /o̯a/**

native (257 word forms): This category includes words in which /o̯a/ appears within the root of a native Romanian word (i.e. not within a morphological ending) or as a result of vowel lowering under stress, a native phonological process. Examples include *floare* 'flower' and *încoace* 'near'.

nativized loan (169 word forms): While these words are etymologically loans, the presence of /o̯a/ in their stressed syllables is not due to the phonological adaptation of a phonetically similar sequence (such as French /wa/ – see the loan/cultismo category below for further explanation); rather, these words have /o̯a/ because the native

Romanian phonological process of diphthongizing under stress has applied to them. Examples include *boală* 'sickness' from Slavic *bolĩ*, *baroană* 'baroness' from French *baronne*, and *episoade* 'act, piece' from French *episode*.

loan/cultismo (150 word forms): This category includes words that were listed in the dictionary as loans, or are clearly 'cultismos', words usually of Romance origin that have been recently adapted to Romanian with minimal phonological changes (Alkire & Rosen 2010). These include *budoar* 'budoir' and *culoar* 'corridor.' Many of these words are of French origin, indicating that Romanian has selected /o̯a/ due to its phonetic similarity to the French glide-vowel sequence /wa/.

origin unknown (25 word forms): These words appear in the online dictionary, but their origin is unknown; an example is *gogoaşă* 'doughnut.'

name (23 word forms): These include words with /o̯a/ which are proper names, such as *Sighişoara*, a Romanian city.

onomatopoetic (2 word forms): Certain instances of /o̯a/ are onomatopoetic according to the online dictionary (DEX 2011), such as *goange* /'go̯an.dʒe/ 'small insect.'

Among words containing the sequence <oa> as a diphthong, a small handful of morphological environments account for most tokens. The two biggest classes are *oare#* and *oasa#*, which together account for nearly 53% of the data. Where /o̯a/ is incorporated into morphological endings, its function in the plural (e.g. *–oane*) is also significant. Compared to /e̯a/, the overall proportion of instances of morphologized

/o̯a/ is lower; this is likely related to the fact that while /e̯a/ can appear in word-final syllables, which are the locus of morphological marking in many cases, /o̯a/ cannot. This restriction is additionally linked to the difference in overall type frequency between /e̯a/ and /o̯a/: the former has more than twice as many occurrences in this corpus, and many of these are in word-final position. The biggest difference between the distributions of /o̯a/ and /e̯a/ comes in the presence of native words in the diphthong's distributional makeup: across all instances of /o̯a/ in the corpus, fully 10% are native, compared to only 2% for /e̯a/.

Despite these distributional discrepancies, /o̯a/ has a place in several morphological endings, such as ethnonyms. As described above for /e̯a/ and /ɨ/, the presence of morpho-phonologically predictable instances of /o̯a/ outweighs that of unpredictable diphthongs in lexical items. The unpredictable instances of /o̯a/ number only 643 words, which form the core of lexical, non-morphologized contrastiveness for that vowel. Even among these native words, /o̯a/ remains restricted to stressed syllables and is subject to metaphony, and given these words' history, it is clear that the diphthong is present as a result of predictable phonological processes. These pieces of evidence support the argument that /o̯a/ is marginally contrastive in Romanian. While it appears in (near) minimal pairs (§3.4.1) and is not highly restricted by segmental context, it is nonetheless true that the presence of /o̯a/ is highly predictable, such that its underlying status is trivial once the context is known.

3.5.3. Summary: Consequences for contrastiveness

In the case of both /e̯a/ and /o̯a/, we find evidence that the role of diphthongs as necessarily lexically-specified underlying vowels is dwarfed by their role as participants in morphological alternations. In other words, in many cases, these diphthongs are necessarily specified in the representations for verbal, adjectival, and

119

nominal morphology and case-marking, but there are many fewer cases in which they must be underlyingly specified in lexical roots. Among words containing /e̯a/, the diphthong appears in an unpredictable context in less than 10% of instances, while for /o̯a/ approximately 27% of words (loans, native words, those of unknown origin, proper names and onomatopoeias) out of 2609 words containing diphthongs fall into this category.

Interestingly, the data for /e̯a/ represent a widening of the phonological contexts in which that diphthong can occur. The evidence for this comes from the fact that in morphologically complex forms such as *cartea* /ˈkarte̯a/ 'the book', the final <ea> sequence is not a phonological diphthong, but a coalescence of the root-final vowel with definite article /a/. This contrasts with the diphthongs' canonical phonological distribution, which is restricted to stressed syllables. It is not clear if <ea> has always been a diphthong in this context; it might be that historically this was a hiatus sequence which has since reduced to a diphthong. In that case, it represents a recent change or change in progress. This does represent an increase in the distribution of /e̯a/, and raises its frequency considerably in the language, but it remains a context in which the diphthong's appearance is highly predictable based on morphological context.

Here I have considered the relative frequencies of these vowels in lexical roots as opposed to their presence in morphological endings or as indicators of specific morphological functions. Even though between one-tenth and one-quarter of each diphthong's occurrences are in roots, those items do not represent the degree to which /e̯a/ and /o̯a/ developed inside the native Romanian lexicon. It has been argued (Schulte 2005) that Romanian uses certain phonemes, such as /ɨ/, as markers of loanwords. Specifically, "a low incidence and functional load of an available linguistic structure can lead to its exploitation as marker of loanwords," and this increase in the use

of the sound in question leads to its incorporation into the standard inventory (Schulte 2005:388). A similar case might be made for the diphthongs, namely that words from Turkish (in the case of /e̦a/) and French (in the case of /o̦a/) are readily adapted with these vowels. Their distribution depends on a combination of native phonological processes, adaptation of phonetically similar sounds, and the exploitation of low-frequency sounds.

The relative prominence, across this type frequency corpus, of /e̦a/ and /o̦a/ among words of different types is shown in 0 below. For each diphthong, the table shows the percentage of words containing a diphthong /e̦a/ or /o̦a/ that are native or proper names, nativized loans, loans or cultismos (the three major categories of lexical items in which diphthongs appear), compared to the number that have morphologized diphthongs.

Table 3.2   Distribution of /e̦a/ and /o̦a/: Largest lexical categories vs.
morphologized diphthongs

Distribution of diphthongs	/e̦a/	/o̦a/
Native and proper names	231 (4% of total)	297 (12.3% of total)
Nativized loans	n/a	169 (7% of total)
Loans and cultismos	227 (4% of total)	150 (6% of total)
Morphologized tokens	5191 (91.5% of total)	1,761 (73% of total)

Only a small proportion of each diphthong appears in native words or proper names. With the addition of loans, these small proportions represent the non-morphological, contrastive, non-predictable core of each diphthong. Consider that the functional load of a contrast might not be strictly phonological or based in minimal pairs, but could instead be based in the members' participation in creating

121

morphological distinctions. In other words, the contrastiveness of a sound might not be evaluated solely on the basis of how many minimal pairs it participates in, but also the range of contexts in which it helps impart morphological information. Additionally, functional load is not the only factor that should be taken into account to evaluate contrastiveness: token frequency also determines how often a given contrast is put to use. While few minimal pairs distinguish e̯a/ from /e/ and /o̯a/ from /o/, for example, the fact that the diphthongs appear prominently throughout morphological endings means that they are often given an important communicative function. The token frequency of /e̯a/ and /o̯a/ is likely higher than their type frequency, due to their heavy use by the morphology; without their presence in verbal and adjectival morphology and loanwords, the diphthongs' role in Romanian would be negligible.

3.6.   Conclusions

The distribution of the three marginally-contrastive vowels of Romanian helps flesh out the range of possibilities for types of phonological contrastiveness, which is not based solely on the presence of minimal pairs separating two phones. Instead, contrastiveness is a multi-dimensional property that additionally depends on relative frequency, the phonological environments in which a segment may appear, and crucially for Romanian, a phone's use within morphological markers, which have the potential to increase token frequency.

While others take into account the relevance of phonological environment (Goldsmith 1995; Hall 2009) and relative frequency (Hall 2009) in describing marginal contrasts, the Romanian facts emphasize the exploitation of certain low-frequency sounds by the morphological system. This in turn increases the phonological contexts in which these sounds can appear and distances them from their historical status as allophones. At the same time, these morphological uses result in

contexts where these low-frequency sounds' presence is highly predictable, and thus can be a dimension along which their contrastiveness is *reduced*. In a model of phonemic robustness in Chapter 6, I lay out a path for quantifying the relative influences of lexical contrast and morphological roles on the independence of a phoneme.

The shifting history of the Romanian lexicon has resulted in strata which reflect not only various influxes of borrowings, but also the effects of the lending languages' phonological makeup on that of modern Romanian. The three marginally contrastive vowels, /ɨ/ /e̯a/ and /o̯a/, have certain characteristics in common: each finds its origins in native allophonic alternations, was pushed towards contrastiveness through the adaptation of loanwords and now can be found in minimal pairs, but retains low type frequency in the modern lexicon. They are marginally contrastive, therefore, in the sense that in one dimension their distribution can (almost) be described. For /ɨ/ this dimension comes from the native vocabulary, in which the vowel is restricted to phonologically-conditioned contexts; for /e̯a/ and /o̯a/ the predictable dimension is their use in contextually-determined, highly regular morphological endings. In each case, though, a second dimension of the vowels' distribution ensures that they figure in underlying representations. For /ɨ/ these are borrowings, and for the diphthongs it is a core of morphologically unpredictable roots, including both native words and borrowings.

The three vowels' marginal contrastiveness is expressed in different ways: /ɨ/ is restricted to a certain set of phonological environments, for example appearing before nasals /n/ and /m/ in over 80% of cases. Additionally, we can describe the marginal contrastiveness in terms of its pairwise relation to /ʌ/: these vowels remain in largely complementary distribution despite the presence of minimal pairs. It is worth recalling that /ɨ/ developed as an allophone of /ʌ/, which in turn was originally in

complementary distribution with /a/; if the morphologically-based word-final contrast between /a/ and /ʌ/ had not occurred historically, these three phones might all be in complementary distribution with one another.

This type of pairwise relationship is the sense of marginal contrastiveness embraced by most other authors on the topic, while the diphthongs represent a different case: they are marginally contrastive within the vowel system as a whole, on the basis of their very low type frequency and the degree to which their distribution across the morphology renders them predictable. /e̯a/ appears in a wide variety of morphological contexts, including occurring in unstressed position as a morphologically complex indicator of definiteness, but is supported by few native items and loanwords (<10% of occurrences). /o̯a/ appears in fewer morphological contexts but in a greater number of native words and borrowings (~25%). Adaptations of borrowings are an important source for each of the three vowels.

Within phonological theory, the difference between these two types of contrastiveness is perhaps analogous to the competing models of Contrastive and Radical Underspecification (Archangeli 1988). In the former, the locus of contrastiveness lies in a segment inventory, and contrast is evaluated from one segment to another, as between the two central vowels. In Radical Underspecification, however, features are the primitive unit, contrast is evaluated with respect to the entire system of available feature specifications, and redundant features may be left unspecified. I argue that the Romanian diphthongs can be characterized in a similar spirit; they do minimally contrast across the lexicon, but are predictable to such a degree that much information about their occurrence need not be lexically specified.

The net result of the processes that gave rise to /ɨ/, /e̯a/ and /o̯a/ is that when we consider any one of these three vowels, based on its distribution in the morphology or phonology, we can predict something about where it will appear – either the

phonological environment in which it will be found, or the morphological context in which it is used. The type frequency-based analyses presented in this chapter show the distributions of Romanian vowels from two different angles: first in terms of their overall type frequency within the language, and second in terms of the contexts in which they appear. While this approach successfully demonstrates the degree to which /ɨ/, /e̯a/ and /o̯a/ are restricted across the lexicon, an alternative tactic is to use relative frequency data to assign numerical values to the contrastiveness of a particular sound.

One analysis of this type comes from Hall (2009), who quantifies the contrastiveness between a pair of sounds, using a calculation based on relative (type or token) frequency and entropy, a measure of a segment's (un)predictability in a given context. While her method does take into account the frequency of segments in order to determine their pairwise contrastiveness, it does not independently allow us to see how frequent the segments are. In other words, the weighted entropies for a high-frequency pair like Romanian /a/ and /e/ might be similar to those of /o/ and /u/, a lower-frequency pair. The present study allows the reader to take the relative frequencies of segments into account only obliquely, by viewing e.g. the type frequency of a segment and separately its rate of occurrence in a specific environment, as in Figure 3.1 and Figure 3.9 for /ɨ/. An ideal model could build on Hall's (2009) system by re-incorporating relative frequency as an additional dimension, which allows us to view not only the relationship within a pair but also its relative frequency with respect to other possible pairs. Additionally, such a model should take into account a phone's morphological role, if any.

Another point of interest is that we do not know the degree to which native Romanian speakers make use of the distributional information available across the lexicon, either for phonological or morpho-syntactic reasons. One way to learn the extent of these effects is through perceptual studies. The results of a pilot perception

125

study (§4.9; Appendix C) show that where the pair of marginally-contrastive vowels [ɨ] and [ʌ] is concerned, [ʌ] is misidentified as [ɨ] in as much as 18% of cases, while [ɨ] is rarely mistaken for its mid-height counterpart. These results may indicate a role for marginal contrastiveness in Romanian vowel perception, namely that less-robust contrasts make identification difficult.

Future perception studies will additionally examine the interaction of phonological context and marginal contrastiveness in vowel perception. Does listeners' knowledge of the distributions of [ɨ] vs. [ʌ] affect segmental identification? For example, do listeners tend to identify stressed pre-nasal vowels as [ɨ] at a greater rate than in other contexts? If they in fact hear the sequence ['ʌn], are they likely to perceive ['ɨn], since the former central vowel rarely occurs in stressed pre-nasal position? Given listeners' propensity to identify [ʌ] as [ɨ], but not vice versa, I indeed predict increased confusion of ['ʌn] with ['ɨn]. This type of experiment, which could be conducted with nonce words given the lexical rarity of ['ʌn] sequences in particular, would test the consequences of marginal contrastiveness for perception.

A second set of experiments could investigate the relationship between marginal contrastiveness and morphology, but from a different angle, for example by testing whether listeners' morphological classification of nonsense words is affected by their phonological content (in particular, the presence of a marginally-contrastive vowel used as a morphological marker). For example, if listeners are given a word ending in ['rɨ], it should be classified as an infinitive; ending in [e̯a], there are several possibilities. These future projects will also take into account the vowels' token frequency, which is hypothesized to be higher for /ɨ/, /e̯a/ and /o̯a/; understanding native speakers' representations of these sounds requires not only knowledge of their distribution across the lexicon, but also their rates of occurrence in everyday speech.

CHAPTER 4: ACOUSTICS OF ROMANIAN VOWELS

4.1.   Introduction

This chapter describes properties of the Romanian vowel system including

general placement of the vowels within the acoustic space, which is understudied. As

outlined in Chapter 1, few modern studies have had the goal of describing Romanian

vowels from a synchronic, instrumental point of view. The chapter has two goals: first,

to present in a general way the methodology used in the experimental portions of this

dissertation; and second, to report the results of a research study on the phonetic

realization of Romanian vowels, focusing on the basic characteristics of the vowel

space, and on the factors affecting vowel duration in Romanian.

As illustrated by Bradlow (1993), the range of vowels that we find in the

world's languages is much smaller than what is physiologically and phonologically

possible; additionally, among what we do find across vowel systems, there is less

variability than might be expected. Given the strong tendencies in the shapes of vowel

systems, it is worthwhile to investigate those with less-common characteristics. The

vowel system of Romanian is unusual in two respects: first, it is unique among

Romance languages in its adoption of two non-low central vowels. Secondly, and

more broadly, the presence of these central vowels is relatively rare across the world's

languages. A measure of this frequency comes from the UPSID database (Maddieson

1984; Maddieson & Precoda 1990), which catalogs the phonological inventories of

languages in a balanced sample of language families. In the enlarged version of

UPSID (Maddieson & Precoda 1990), also available on the World Wide Web,[33] 451

languages are surveyed; the frequencies of the phonemic vowels of Romanian, as

measured across these languages in UPSID, appear in Table 4.1.

---

[33] http://web.phonetik.uni-frankfurt.de/UPSID.html

Table 4.1.   **Typological frequency, in UPSID database, of phonemic**

vowels in Romanian

Vowel	Percentage of UPSID languages
/i/	87.14%
/a/	86.92%
/u/	81.82%
/o/	29.05% ("lower mid" back vowel)
/e/	27.49% ("higher mid" front vowel)
/ʌ/	16.85% (/@/ in UPSID online database)
/ɨ/	13.53%
/o̯a/	2 languages (Romanian and !Xu)
/e̯a/	1 language (Romanian)

While the three point vowels /i a u/ each appear in over 80% of languages represented by UPSID, /ɨ/ and /ʌ/ are much rarer; additionally, Romanian is the only UPSID language with both /e̯a/ and /o̯a/. In terms of height and backness, mid vowels are slightly more common than high vowels; and front vowels are more common than back vowels, which in turn are more common than central vowels. Unround vowels are more common than rounded vowels (Maddieson 1984). Returning to the central vowels of Romanian, we note that /ɨ/ appears in 61 out of 451 languages, while /ə/ occurs in 76 languages in the database; by comparison, the most frequent vowel /i/ appears in 393 languages. We can conclude that for a language to have both these vowels as phonemes indicates typological unusualness.

As a comparison, consider the vowel system of Romanian next to that of Italian which, in addition to being another Romance language, is compared to Romanian in Chapter 5:

Table 4.2.   **Phonemic vowels in Romanian and Italian**

Romanian		
/i/	/ɨ/	/u/
/e/	/ʌ/	/o/
/e̯a/	/a/	/o̯a/

Italian	
/i/	/u/
/e/	/o/
/ɛ/	/ɔ/
/a/	

The lower mid vowels of Italian are typologically more common than the central vowels of Romanian: /ɛ/ appears in 41.24% of languages in UPSID, while /ɔ/ is present in 35.92% of them (Italian is not in the UPSID database). Apart from the relative height of its mid vowels and the presence of diphthongs, the Romanian vowel system is somewhat typical for the number of phonemes it contains. It is not 'defective' (Maddieson 1984), i.e. having a large gap such that the front and back portions of the system are asymmetrical, and it has one of the most common inventories for seven-vowel systems (Lindblom 1986), excluding the diphthongs.

From a theoretical point of view, the vowel inventory of Romanian can be compared with what is predicted by Lindblom (1986) regarding models for the shapes and makeup of typical vowel inventories. Lindblom bases his models on Crothers' (1978) typological inventory, which served as the starting point for the UPSID database used by Maddieson (1984). According to Lindblom (1986:14–15), the most common phonemic vowels are /i, ɑ, u/, followed by /e, ɛ, o, ɔ/, and then /ɨ, ə/. By this measure, Romanian has vowels that are not unexpected given the number of phonemes it has; the unpredicted aspect is, again, its phonemic diphthongs /e̯a/ /o̯a/, which historically developed from /e, o/ in stressed position (Alkire & Rosen 2010).

However, by Lindblom's calculations, Romanian has exactly the vowel inventory expected for a system of its size (with the exception of the diphthongs). Lindblom (1986), as well as Liljencrants and Lindblom (1972) and Lindblom et al. (1984) argue for the idea of Adaptive Dispersion Theory, under which the vowels in a language are predicted to maximally spread to the margins of the vowel space, providing a vocalic framework which allows speakers to give maximal contrast and distinctiveness to their productions, ostensibly easing communication. However, the models tested by these works are unable to successfully place central vowels such as /ɨ, ə/ in accordance with typological observations.

Given these typological facts, the vowel system of Romanian merits investigation, with a particular focus on the realization of the central vowels and diphthongs /e̯a/ and /o̯a/. This study provides a better understanding of the acoustics and patterning of the central vowels and diphthongs in this otherwise typical vowel inventory. Romanian furthermore offers ample comparisons to better-studied, genetically related languages such as Italian, a relationship I take advantage of in Chapter 5. Thus this chapter focuses on determining the properties of the individual vowels, largely without taking into account the effects of surrounding phonological environment. It provides basic observations about the qualities of Romanian vowels that form the basis of the experiment presented in Chapter 5, which examines the vowels in context and measures the degree to which they coarticulate at a sub-allophonic level with flanking vowels and consonants.

Before delving into the phonetic results, we first set the stage for these phonetic experiments by describing the methodological features that they have in common.

4.2.   Experimental methodology: An overview

This section presents a summary of methodological techniques used throughout the phonetically-based portions of this dissertation, while leaving the details of each experiment (i.e. word lists) to the section or chapter focusing on its results and analysis. This dissertation includes three production experiments: one on the basic acoustics of Romanian monophthongs (§4.3); a second on the diphthongs /e̯a/ and /o̯a/ (§4.7); and a third comparing Romanian vowels to those of Italian (Chapter 5). The methodologies and implications of these studies differ, but they overlap in terms of their participants, recording and analysis techniques. Additionally, two pilot studies of vowel perception in Romanian are discussed briefly in §4.9 and also described in Appendix C. Together, the work collected here represents a significant contribution to the data available on the Romanian language.

The data analyzed in this dissertation were collected largely at Cornell University and at Babeş-Bolyai University in Cluj-Napoca, Romania. Acoustic data were also collected in Sasso Marconi, Italy; and by Ioana Chiţoran at Dartmouth College, and by Catalina Iricinschi in northeastern Romania.

4.2.1.   Stimuli

The stimuli recorded for this dissertation were prepared in consultation with Ioana Chitoran. Generally, the goal of the acoustic experiments is to evaluate the phonetic characteristics of Romanian vowels, with particular attention to formant values (F1, F2) and duration. The acoustic experiments target all seven phonemic vowels of Romanian, plus two diphthongs. Stimuli for the perceptual experiment, listed in Appendix C, were also analyzed with the techniques described here. To an extent made explicit in each acoustic experiment's chapter, controls in these studies included the following aspects:

131

1. Vowel quality. Romanian has seven phonemic monophthongal vowels: /i/ /ɨ/ /u/ /e/ /ʌ/ /o/ /a/; and two diphthongs are also examined, /e̯a/ and /o̯a/.

2. Stress. Vowels in Romanian are either stressed or unstressed; synchronically there is no reduction in unstressed syllables. Stress typically falls on the root-final syllable (Chiţoran 2002b).

3. Syllable count. In a given word, vowels' duration is known to be affected by the number of syllables (Peterson & Lehiste 1960; Lehiste 1972); in order to study the relationship between syllable count and duration, this factor was controlled.

4. Adjacent segments. Coarticulation with adjacent segments can affect vowels' formant values. To minimize these effects and achieve the clearest vision of the Romanian vowel space, voiceless obstruents were placed next to target vowels whenever possible; liquids and nasals were avoided except in minimal pairs between /ɨ/ and /ʌ/.

For recording, the following frame sentence was used: *Spune X de trei ori* ['spune ___ de trej orʲ] 'Say X three times,' in which X is the target word. Once the target words were placed in frame sentences, the sentences were assigned numbers and randomized. Participants read the randomized stimuli at a normal rate of speech, neither slowly nor quickly, and were asked to repeat a stimulus if they made a mistake. Speakers were allowed to look over the word list prior to recording, to familiarize themselves with the content; for each set of stimuli, speakers read through the entire set three times.

Recordings at the Cornell Phonetics Laboratory took place in a sound-attenuated booth, where a Marantz digital recorder and a stand-mounted microphone were used. At Dartmouth College, recordings took place under similar conditions. In

Romania, speakers were recorded in quiet surroundings, via a head-mounted Sennheiser 156 headset with microphone, onto a laptop. All recordings were made digitally, sampling at 44 kHz. Speakers were compensated for their time. Recordings took place between December 2009 and February 2011.

4.2.2. Data labeling

Each speaker's data was labeled using Praat (Boersma & Weenink 2010). For each .wav file, a Text Grid was created with interval tiers for the annotation of vowel type, stress (when relevant), word, and repetition number (1-3). Each of those intervals was labeled for each stimulus. When labeling vowels, I placed the beginning label at the onset of the second formant of the vowel (as shown by the spectrogram); the onset of F1 sometimes coincided with noise from the preceding consonant and was not a reliable indicator of vowel onset. I placed the ending label at the offset of F2, as shown by the spectrogram, or at the point where the spectrogram and wave form showed an abrupt shift towards the acoustic characteristics of the following consonant or word-final silence. An example spectrogram and wave form for the target word *mă* /mʌ/ 'me' (from *Spune mă de trei ori*) appear in Figure 4.1, which additionally shows boundary placements near the target vowel.
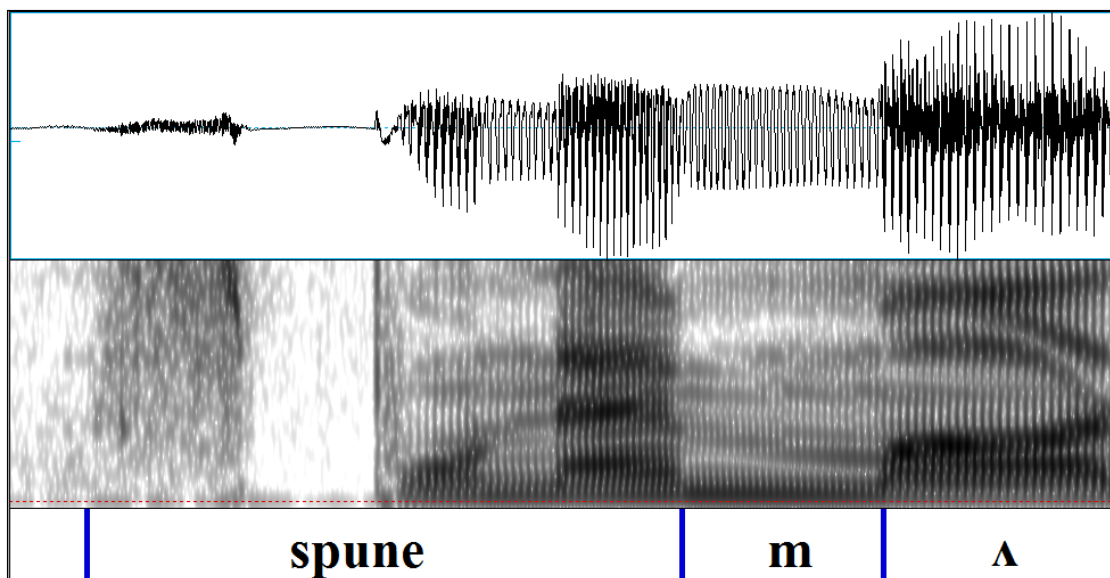
Figure 4.1.   **Spectrogram: [spune mʌ de trej orʲ]**

4.2.3.   **Data extraction and analysis**

To analyze acoustic vowel data, a Praat script was used to extract information from the Text Grids and corresponding sound files. The following acoustic information was gathered for each vowel: duration of the vowel, the first three formants (F1, F2, F3) at one quarter the duration of the vowel, and the first three formants at the vowel midpoint. Once these measurements had been compiled, they were hand-checked for formant tracker errors, both by graphing each vowel's F1/F2 and looking for unusual values; and by examining the formant values in a spreadsheet and looking for unexpected measurements. Analyses were conducted using Microsoft Excel, JMP, and SAS software. Once the data were compiled into a spreadsheet, additional columns of information were added for each data point, including language, gender, speaker number, file name, repetition, flanking segments, stress, and word.

Some acoustic data, especially those collected for Chapter 5, were normalized for statistical analysis and comparison across speakers and genders. Normalization was performed by first calculating the mean F1 and F2 values across vowel types, for

all a speaker's data (as measured at vowel midpoint), and then subtracting that mean value from each individual measurement. This technique transforms the data so that each speaker's results are centered at a mean of (0, 0); however, it does not eliminate gender differences, which are relevant as described in §4.6. Where statistical analyses involving both genders' data were necessary, Z-scores (calculated using the normalized value divided by the standard deviation for that speaker) were used instead. This calculation was intended to factor out the greater variability (manifested as a greater total formant value range) of the female speakers.

4.2.4. Field work

A large portion of the data collection for this dissertation was carried out during a month-long field work trip to Romania, where I traveled in September 2010. I was hosted at Babeş-Bolyai University in Cluj-Napoca, Romania, in the Center for Modern Languages in the University's Faculty of Letters. A portion of the perceptual experimentation reported here was conducted at the Center for Modern Languages and in homes and offices around Cluj-Napoca; and several recordings took place at the Phonetics Laboratory in the Faculty of Letters. Other recordings in Cluj-Napoca were made in quiet home environments. In addition to the data reported here, I also elicited a small amount of data demonstrating the properties of regional Ardelean dialects from the area around Cluj-Napoca, by both phonetic transcription and recordings.

4.2.5. Participants

Across both Romanian and Italian, and all experiments reported here, a total of 25 individual speakers were recorded. Several speakers participated in multiple experiments or recording sessions. Nine speakers were recorded in Romania; one in Italy; two at Dartmouth College, and the remaining thirteen at Cornell University. In

135

the perceptual experiment, of which there were two versions, a total of 48 individuals participated. Of these, 41 participated in the original version of the experiment, conducted in September 2010 at Babeş-Bolyai University in Cluj-Napoca, Romania. The remaining seven participated in an expanded version of the experiment, which took place in early 2011 at Cornell University.

The Romanian speakers recorded in the experiments reported here come from a variety of locations within Romania, and additionally, roughly half of them were living in the United States at the time of recording. I collected information on their Romanian home region, and also how long they had lived in the United States, when applicable. While all spoke standard Romanian, there are regional differences in accents across the country. Figure 4.1 is a map showing the major dialect areas of Romania. Cluj-Napoca is in the Ardelenesc area, while the capital Bucharest is in the Muntenesc zone. A summary of each speaker's linguistically-relevant biographical information, including their home dialect region, appears in Table 4.3.

Figure 4.1.   **Dialect distribution (Wikipedia)**

Table 4.3. **Speaker information, including the number of years the speaker has spent in the USA, and recording location. The prefix *F* indicates a female speaker; *M* indicates a male speaker.**

Speaker	Recording location	Years in US	Romanian language area
F1	Cornell	5	Moldovenesc
F2	Cornell	10	Muntenesc
F3	Dartmouth	2	Muntenesc/Moldovenesc
F4	Romania	0	Moldovenesc
F5	Romania	0	Moldovenesc
F6	Cornell	1.5	Muntenesc/Moldovenesc
F7	Cornell	0.6	Moldovenesc
F8	Romania	0	Ardelenesc
F9	Romania	0	Ardelenesc
F10	Romania	0	Ardelenesc
F12	Romania	0	Ardelenesc
F13	Romania	0	Ardelenesc
F14	Cornell	5	Ardelenesc
F15	Cornell	4	Muntenesc
M1	Romania	0	Bănăţean/Oltenesc
M2	Cornell	4	Oltenesc
M3	Dartmouth	4	Moldovenesc

4.2.5.1. Speaker dialect: A relevant factor?

The experiments in this dissertation are concerned with, among other things, determining whether /ɨ/ and /ʌ/ are fully-contrastive or reduced vowels in Romanian. One way to approach this question is by considering the phonetic variability of these

vowels, which might be greater if they are actively phonologically reduced, as they are in American English. The phonetic variability of central vowels /ɨ/ and /ə/ has been shown to differ systematically in American English (Flemming & Johnson 2007). Specifically, the formant values of /ə/ in English depend greatly on the consonants flanking them, while /ɨ/ is restricted to a smaller region of the vowel space. Given this phenomenon, I was concerned that speakers' production of /ʌ/ and /ɨ/ in Romanian might be related to the length of time they had lived in the US, and that speaking English might affect the variability of /ɨ/ and /ʌ/ in their productions of Romanian vowels. To check for such an effect, I measured vowel quality variability in the tokens recorded for the discussion of basic vowel acoustics (see §4.4), by comparing the standard deviations of the second formant in both /ɨ/ and /ʌ/.

The results of this comparison are summarized in the figures below, which are separated by formant; each figure is subdivided by speaker location (Romania or USA). These figures show the *difference* in standard deviations between /ʌ/ and /ɨ/, across each speaker's data; each data point was calculated by subtracting the standard deviation in F1 or F2 of a speaker's /ʌ/ tokens from that of their /ɨ/ tokens (e.g., $(SD_{/ɨ/} - SD_{/ʌ/})$). If Romanian speakers have adopted an American English pronunciation of /ʌ/, I predict its variability to be much higher than that of /ɨ/, resulting in high negative numbers in this calculation, with a different pattern among Romanians living in Romania. Figure 4.2 shows differences in F1 standard deviations, while Figure 4.3 shows them for F2.
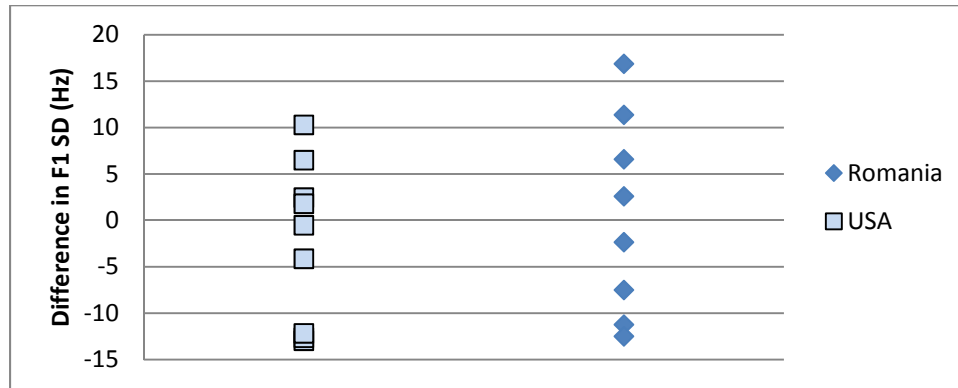
Figure 4.2.   **Difference in standard deviations of F1 (SD$_{/i/}$ – SD$_{/ʌ/}$):**

Speakers recorded in Romania and USA
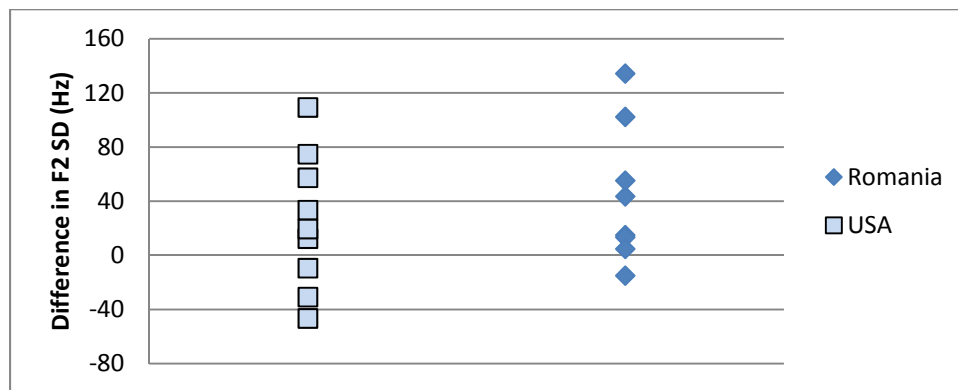
Figure 4.3.   **Difference in standard deviations of F2 (SD$_{/i/}$ – SD$_{/ʌ/}$):**

Speakers recorded in Romania and USA

Across the results for speakers in Romania and the USA, no distinct pattern emerges: the differences in standard deviations do not cluster consistently, in either recording location or for either formant. Speakers recorded in Romania tend to have slightly higher SD differences than those recorded in the USA, indicating that /ɨ/ tends to be more variable than /ʌ/; however, the overall effect is very small.

Across the two locations, the differences in standard deviation between /ʌ/ and /ɨ/ are comparable, indicating that while speakers *do* produce the central vowels with differing rates of variability, those rates are not linked to influence of a second

language. Variability in central vowel production appears to be a speaker-specific characteristic. Given this result, the experiments described in this dissertation will not further consider the influence of L2 English on speakers' production, while gender and Romanian language area will be considered as needed in individual experiments.

Having described the general methodologies used for phonetic experimentation in this dissertation, I now turn to the first of these experimental studies, which focuses on the basic acoustics of Romanian vowels.

4.3.   Acoustics of Romanian vowels

I use this phonetic study to first describe the basic characteristics of the Romanian vowel space, focusing primarily on its seven monophthongal phonemic vowels, and briefly examining two diphthongs. The methodology includes an examination of vowel space in terms of the first and second formants (F1 and F2), in which various levels of data pooling are applied, to discover what main factors affect these formants in Romanian. Data across speakers are found to be reasonably consistent, with similar arrangements of vowels within the F1-F2 space. Several results, including the distribution of vowels across the space, their rates of variability, and the effects of stress, indicate that the central vowels /ɨ/ and /ʌ/ are as acoustically consistent as the peripheral vowels. This demonstrates their stability within the vowel system and supports their status as full, not reduced, vowels.

The second goal of the phonetic study is to examine vowel duration, to determine the basic factors that affect it in Romanian. I find that stress, vowel height, syllable structure (presence or absence of coda), and final lengthening (or polysyllabic shortening) all have an effect on duration, although variation across speakers also occurs.

4.4.   Methodology

The general methodological techniques used in this study and others in this dissertation are described above, in §4.2.

4.4.1.   Stimuli

The target vowels in this study were elicited in Romanian lexical items, embedded in a frame sentence. The word list was prepared with help from Ioana Chițoran. Romanian has seven phonemic single vowels: /i/ /ɨ/ /u/ /e/ /ʌ/ /o/ /a/. I tested each vowel in at least four words. Due to the low type frequency of /ɨ/ in particular, the list necessarily contained several rarely-used words. Each of the seven vowels was targeted minimally in two separate stressed syllables and two separate unstressed syllables (with more for /ɨ/ and /ʌ/). The number of syllables in each target word was controlled with the goal of reducing durational variability, since the duration of a given vowel is expected to decrease as the number of syllables in the word increases. All target words for /i/, /u/, /e/, /o/ and /a/ were kept at two syllables. Target words for /ʌ/ and /ɨ/ contained between one and three syllables. Efforts were also made to control the segments adjacent to each target vowel: for all seven vowels I avoided placing nasals (/n/, /m/) and liquids (/r/ and /l/) before and after target vowels. However, specifically for /ʌ/ and /ɨ/ I also included stimuli in which the target vowel was historically phonologically conditioned by an adjacent nasal or liquid. Finally, to investigate the nature of the contrast between /ɨ/ and /ʌ/, I recorded all the known minimal pairs between those two vowels.

4.4.2. Word list

A list of the recorded words appears in Table 4.4 below, with words listed by vowel, stress condition, and presence of historical phonological conditioning (as discussed in Chapter 2); plus whether they are part of a minimal pair within the list.

Table 4.4.   **Investigation of Romanian vowel space: Word list**

	Transcription *Target vowel is **bold**.*	Orthography	Gloss	Stress	Phonological conditioning?	Minimal pair?
1	ur'k**a**	urca	ascend	STR	n/a	No
2	'g**a**ta	gata	ready	STR	n/a	No
3	k**a**'pak	capac	lid	UNS	n/a	No
4	d**a**'ta	datá	date (inf.)	UNS	n/a	No
5	't**e**ta	teta	theta	STR	n/a	No
6	ko't**e**ts	coteţ	coop	STR	n/a	No
7	'kudʒ**e**t	cuget	thought	UNS	n/a	No
8	'dedʒ**e**t	deget	finger	UNS	n/a	No
9	tʃi't**i**	citi	read (inf.)	STR	n/a	No
10	ku'ts**i**t	cuţit	knife	STR	n/a	No
11	k**i**'ti	chiti	ask	UNS	n/a	No
12	g**i**'tʃit	ghicit	guessed	UNS	n/a	No
13	'l**ɨ**nʌ	lână	wool	STR	_N	No
14	'**ɨ**ndʒer	înger	angel	STR	_N	No
15	'k**ɨ**mp	câmp	camp, field	STR	_N	No
16	'v**ɨ**r	vâr	I thrust	STR	_R	Yes
17	'ts**ɨ**rʌ	ţâră	a little (f. sg.)	STR	_R	Yes
18	'k**ɨ**rtitsa	cârtiţa	mole (animal)	STR	_RC	No
19	'd**ɨ**	d	d (letter)	STR	n/a	Yes
20	'g**ɨ**skʌ	gâscă	goose	STR	n/a	No
21	'f**ɨ**	f	f	STR	n/a	Yes
22	'm**ɨ**	m	m	STR	n/a	Yes
23	'k**ɨ**	c	c	STR	n/a	Yes
24	a't**ɨ**t	atât	than	STR	n/a	No
25	's**ɨ**	s	s	STR	n/a	Yes
26	'b**ɨ**tʌ	bâtă	club (instr.)	STR	n/a	No
27	'r**ɨ**de	râde	(he) laughs	STR	R_	No
28	'r**ɨ**zʲ	râzi	you (sg.) laugh	STR	R_	No
29	'r**ɨ**w	râu	river	STR	R_	Yes
30	omo'r**ɨ**	omorî	kill	STR	R_	No

31	tɨr'ziw	târziu	late	UNS	_RC	No
32	kɨr'nat	cârnat	sausage	UNS	_RC	No
33	gɨdi'la	gâdila	tickle	UNS	n/a	No
34	gɨtu'i	gâtui	strangle	UNS	n/a	No
35	'totul	totul	all (m.sg. def.)	STR	n/a	No
36	'tobʌ	tobă	drum	STR	n/a	No
37	ko'pii	copii	children	UNS	n/a	No
38	to'tal	total	total	UNS	n/a	No
39	'sutʌ	sută	one hundred	STR	n/a	No
40	'dute	du-te	take yourself (imp.)	STR	n/a	No
41	du'tʃe̯a	ducea	led (3sg. impf.)	UNS	n/a	No
42	pu'tja	putea	be able	UNS	n/a	No
43	'bʌntʃʲ	bănci	banks (fisc.)	STR	_N	No
44	'vʌr	văr	cousin	STR	_R	Yes
45	'tsʌrʲ	ţări	lands (noun)	STR	_R	Yes
46	'kʌrtsʲ	cărţi	books	STR	_RC	No
47	'kʌrtsile	cărţile	the books	STR	_RC	No
48	'mʌ	mă	me (acc.)	STR	n/a	Yes
49	'dʌ	dă	(he) gives	STR	n/a	Yes
50	'sʌ	să	that (conj.)	STR	n/a	Yes
51	'kʌ	că	that (conj.)	STR	n/a	Yes
52	fakul'tʌtsʲ	facultăţi	departments	STR	n/a	No
53	'fʌ	fă	girl (interj.)	STR	n/a	Yes
54	'dʌtsile	dăţile	give them (imp.)	STR	n/a	No
55	a'pʌs	apăs	oppression	STR	n/a	No
56	'pʌturʲ	pături	beds	STR	n/a	No
57	'strʌzʲ	străzi	streets	STR	R_	No
58	'rʌw	rău	bad	STR	R_	Yes
59	'pʌtuts	pătuţ	bed (dim.)	UNS	n/a	No
60	kʌ'de̯a	cădea	fall (inf.)	UNS	n/a	No

4.4.3. Participants

The experiment had 18 participants. Eight were recorded at Cornell by the

author; two at Dartmouth, by Ioana Chiţoran; three in Romania by Catalina Iricinschi;

and six in Romania by the author. One male speaker's data was discarded because he

had lived in the US and Canada since age 12, and he was not familiar with all the

words in the stimuli. One female speaker's data (F7) were re-recorded because she spoke very softly, with only data from the second (louder) recording included in the analysis.

4.5.   Results

To examine the acoustic properties of Romanian vowels, in relation to one another, extracted formant data were used to construct an F1-F2 graph demonstrating the vowel space of Romanian (as described in e.g., (Johnson 1997; Ladefoged & Johnson 2011). This technique is based on the correlations between values of the first two formants, and acoustic and phonological characteristics of vowels: the first formant correlates inversely with vowel height, such that a low vowel /a/ has a high F1, but high vowel /i/ has a low F1; and F2 correlates positively with vowel frontness, such that a front vowel /i/ has a high F2, but a back vowel /u/ has a low F2. These correlations are schematized in Figure 4.4 for /i/, which is a high front vowel; for the low vowel /a/; and for the high back vowel /u/. Note that F1 has a smaller overall range than F2; for this reason, we may expect to find less variability in F1 than F2, within the acoustic realizations of a single vowel type (Kent & Read 1992).
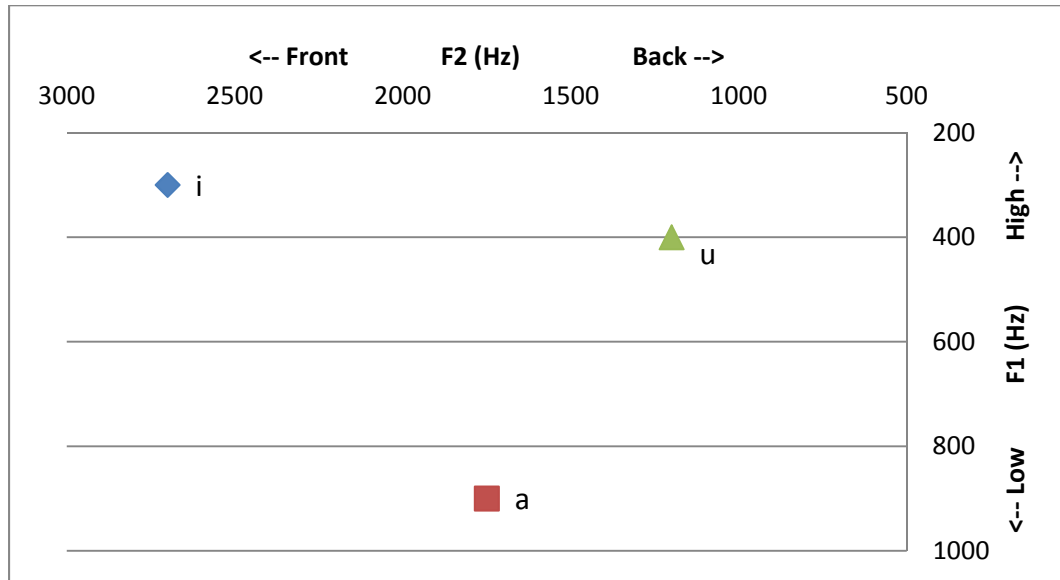
Figure 4.4.　**Schematized F1-F2 vowel space (not based on Romanian data)**

By measuring how the vowels' acoustics map onto this space, we can observe the acoustic distance between a given pair of vowels; and we predict that these distances also correlate with auditory or perceptual differences, and may be related to phonological processes involving vowels.

4.6.　The vowel space of Romanian

In this section, I present an analysis of the Romanian vowel space which details the acoustic characteristics of monophthongs in both stressed and unstressed condition, as well as those of the diphthongs. The analysis focuses primarily on formant values from F1 and F2, as well as their variability.

4.6.1.　Characteristics of stressed monophthongs

To examine the vowel space in Romanian, stressed and unstressed vowels are presented separately; I first present data from stressed vowels. Figure 4.5 plots the first

two formants of Romanian vowels (F1 vs. F2), under stress, as produced by the 14 female speakers recorded in this study; Figure 4.6 shows the same data from the study's three male speakers. Each point on these graphs represents the midpoint of a different vowel token; formant values were *not* normalized across speakers.[34]

The vowels included in these two figures are the phonemic monophthongs of Romanian: /i/, /ɨ/, /u/, /e/, /ʌ/, /o/, /a/. A standard phonological analysis of Romanian, however, also includes two diphthongs: /e̯a/ and /o̯a/. Since diphthongs are characterized acoustically by movement of the formants from one set of values to another, it is difficult to graph their data points with other monophthongs, and they are excluded from the initial graphs for simplicity's sake. Diphthong data are included in less-complex figures showing mean formant values, or those of single speakers (§4.7).
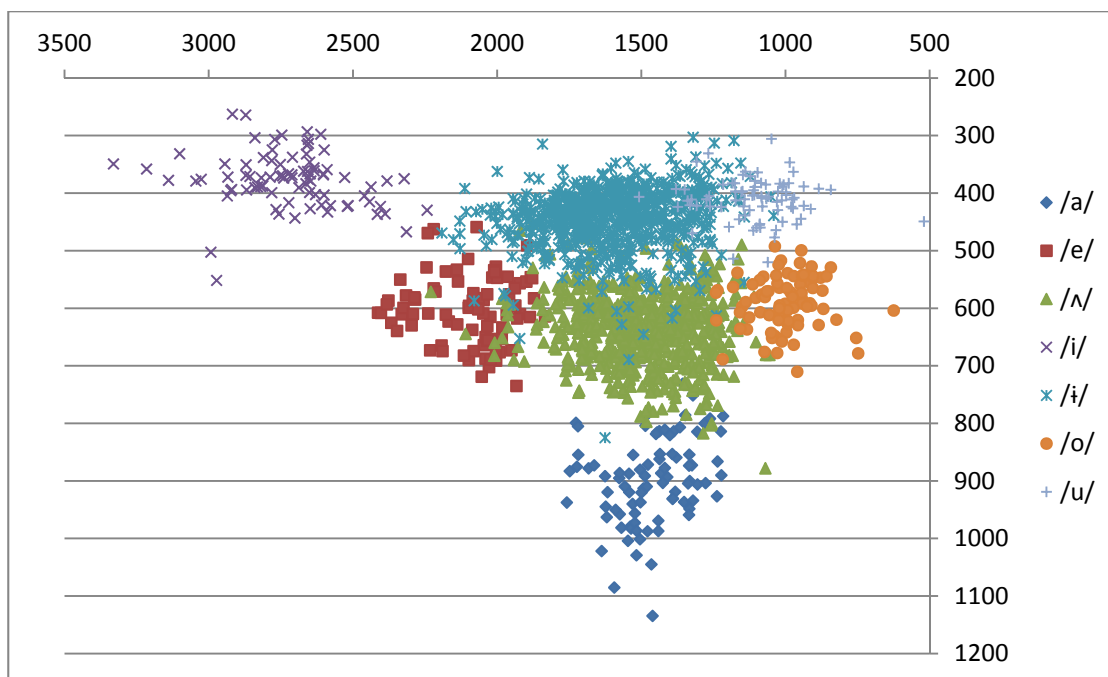
Figure 4.5.   **F1 and F2 of stressed vowel tokens, female speakers of Romanian (14 speakers; non-normalized data)**

---

[34] Normalization procedures are detailed in §4.2.3.

146
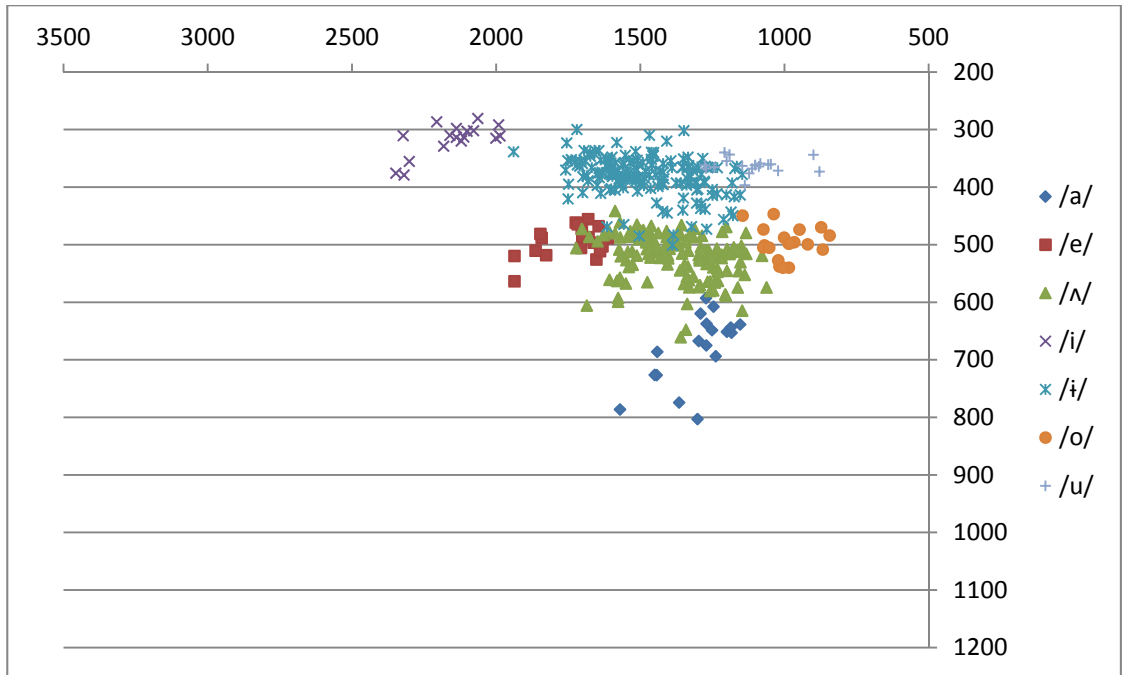
Figure 4.6.   **F1 and F2 of stressed vowel tokens, male speakers of Romanian (3 speakers; non-normalized data)**

In Figure 4.5, the total range of F1 values for female speakers extends from approximately 250 Hz (for /i/) to nearly 1200 Hz (for /a/). In F2, the farthest-back vowel, /o/, has values as low as 625 Hz, while some values for /i/ are more than 3300 Hz. Turning to the male speakers' data in Figure 4.6, however, the total F1-F2 range of male speakers is smaller than that of female speakers. Male speakers' F1 values range from approximately 250 Hz (/i/) to nearly 900 Hz for /a/; and the F2 values are as much as 2400 Hz (/i/) and as low as 800 Hz (/a/). In other words, female speakers have a total F1 range of roughly 850 Hz and an F2 range of 2800 Hz, but male speakers' F1 range spans only 650 Hz, and their F2 spans 1600 Hz. Since this is true even for normalized formant values (not shown here), it indicates that female speakers in this study have a wider acoustic vowel space than males in this study, which means that formant values cannot be directly compared across genders.

147

The difference in formant ranges between male and female speakers may follow from what is known about the anatomical differences between speakers of each gender. Men typically have longer vocal tracts than women, meaning that their voices have a lower fundamental frequency (f0); for example, a typical male f0 might be 100Hz, while females' f0 could be 200Hz. Vowel harmonics and resonant frequencies (including F1 and F2) are multiples of the fundamental frequency f0. Since males have longer vocal tracts and therefore lower f0 than females, we expect all their formants to be lower and contained in a smaller range than those of females (Titze 1989; Kent & Read 1992).

Phonologically, the Romanian vowel system is symmetrical from front to back: it has three high vowels (front, central and back), three mid vowels at the same degrees of backness, and a single, phonologically central low vowel /a/. We might expect *a priori* to find that the phonetic realizations of the vowels are also symmetrical, such that high vowels /i/, /ɨ/ and /u/ all have comparable low F1 values, and that central vowels /ɨ/, /ʌ/ and /a/ all have comparable F2 values. We might also expect a triangular vowel space in which high vowels occupy a greater F2 range than lower ones. The relative positions of vowel-type clusters in Figure 4.5 show generally symmetrical placements from front to back, except in the case of /i/, which is markedly different: /u/, /ɨ/, /o/, /ʌ/ and /e/ lie close together within a range spanning about 800 Hz in the first formant, and 1600 Hz in the second formant. There is considerable overlap among some vowels, especially /ɨ/ and /u/, and to a lesser extent between /ɨ/, /e/ and /ʌ/, and between /ʌ/ and /o/. By contrast, /i/ is clearly very high and very front, with F1 values considerably lower and F2 values considerably higher than the other Romanian vowels. The same generalization, regarding the acoustic location of /i/ relative to the other vowels, is true for male speakers (Figure 4.6); regardless of

the differences in acoustic size of the vowel space, the vowels' placement with respect to one another is roughly equivalent across the two genders.

The phonetic realization of /i/ is surprising given the phonologically symmetrical vowel inventory, and it is potentially important in the language. Since /i/ is phonologically a high front vowel, thus sharing frontness characteristics with /e/ and height characteristics with /ɨ/ and /u/, we might expect it to be acoustically located at the same F2 range as /e/, and the same F1 range as /ɨ/ and /u/. There is a relationship among the central vowels /a/, /ʌ/, /ɨ/: these differ in F1 (height), but the clusters of their F2 values are nearly equivalent. In this way, the three vowels appear to clearly share the same central articulation, while differing only in height, paralleling the phonological analysis. However, /i/ has more extreme formant values than any of the vowels with which it shares features. This fact may correlate with effects we see in the phonology, in which /i/ historically triggered (and triggers synchronically) many alternations of both vowels and consonants. The vowels /i/ and /a/ represent extremes in the vowel space, which is interesting since they are also the opposing forces in vowel harmony: /i/ has the effect of monophthongizing and raising preceding vowels, while /a/ follows diphthongs and other non-front (or non-raised) vowels. The results also echo Chiţoran's (2002b) finding that /e/ and /i/ have greater acoustic separation in the vowel space than /o/ and /u/, which she hypothesizes is linked to greater similarity across diphthong/glide-vowel sequences in back-vowel than front-vowel sequences.

The data in these figures additionally reveal the phonetic realization of the non-low central vowels /ɨ/ and /ʌ/. Given their marginally contrastive status, and the nearly-complementary relationship between these two vowels, we might predict them to show characteristics of reduced vowels. In this case, their formant values could be highly variable and highly context-dependent, overlapping with one another in the acoustic space. Instead, these results show that the central vowels are quite distinct

149

from one another acoustically; they overlap very little in the acoustic space. Where they do overlap (in the range of 550 Hz for females and 450 Hz for males), /ɨ/ and /ʌ/ intrude no more into one another's acoustic space than they do into that of the other adjacent vowels – /e/ and /o/ for /ʌ/, and /i/ and /u/ for /ɨ/. This is evidence that, despite their phonological properties, the central vowels' acoustic characteristics are comparable to those of full vowels.

4.6.2. Characteristics of unstressed vowels

Cross-linguistically, a common phenomenon is acoustic vowel reduction in unstressed vowels. This is often realized as centralization, which is a result of speakers' failure to attain the vowel's full articulatory target during its relatively shorter duration. Here, the analysis of each speaker's data included a minimum of six tokens of each monophthong in unstressed position, permitting comparison of the basic acoustic characteristics of stressed and unstressed vowels in Romanian. These results are shown for the 14 female speakers in Figure 4.7, and for the three male speakers in Figure 4.8, below. These figures contain fewer data points than those shown above because fewer unstressed than stressed target vowels were included in the study.
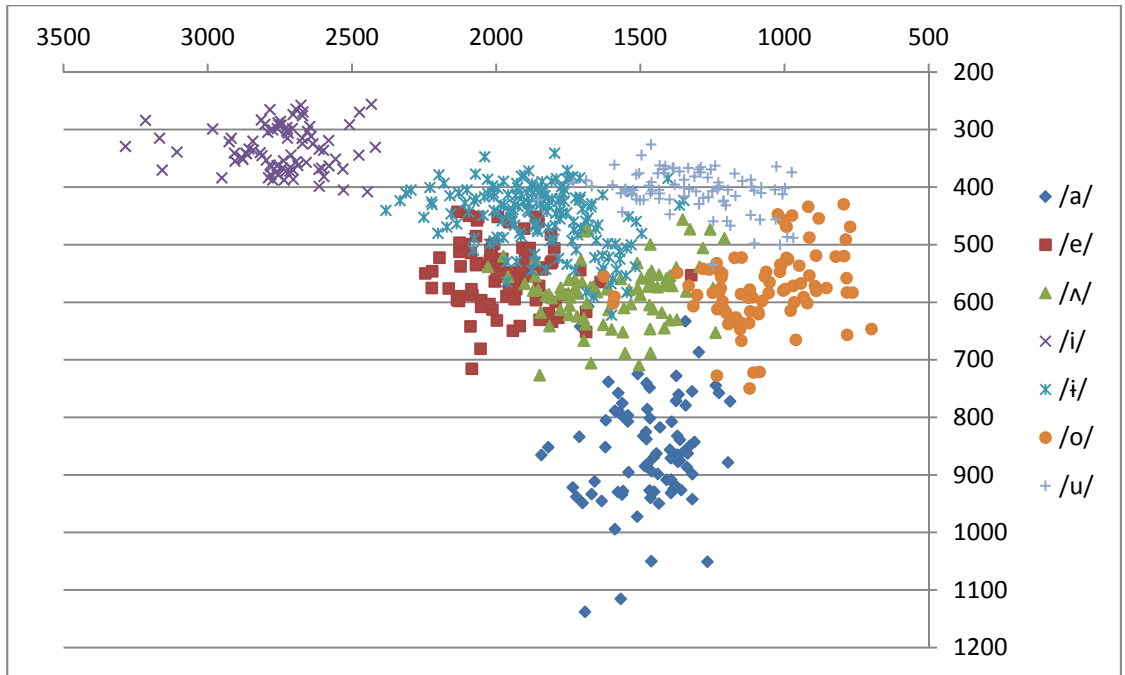
Figure 4.7. **F1 and F2 of unstressed vowel tokens, female speakers of Romanian (14 speakers; non-normalized data)**
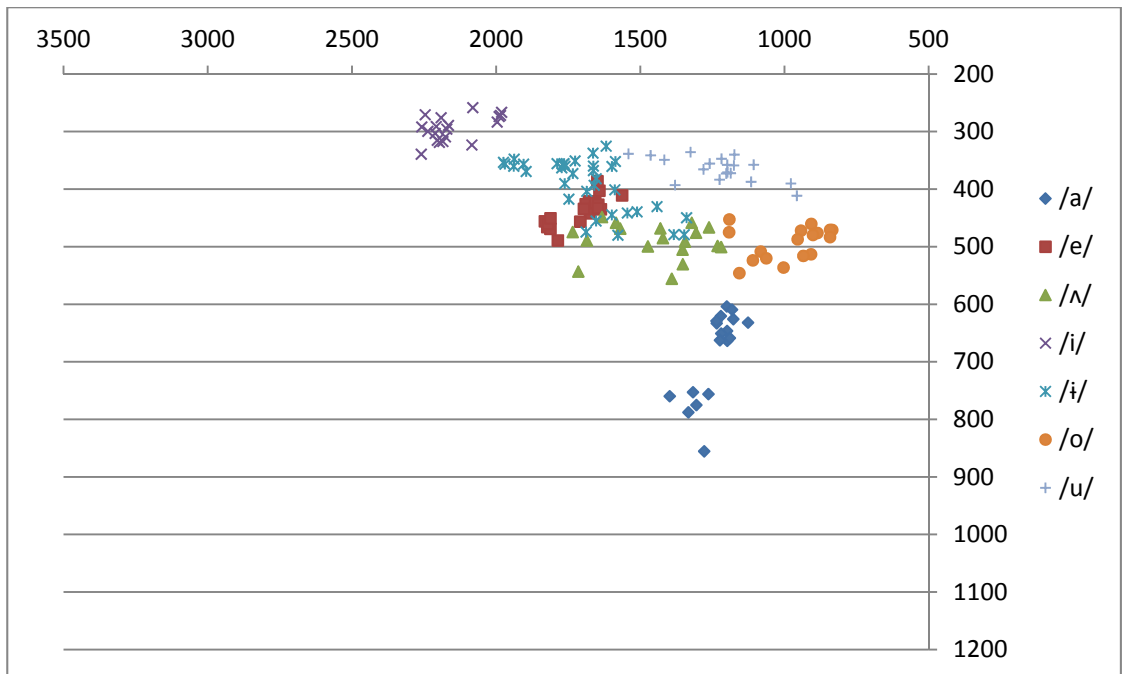
Figure 4.8. **F1 and F2 of unstressed vowel tokens, male speakers of Romanian (3 speakers; non-normalized data)**

With visual examination, the unstressed vowels of Romanian appear to occupy the same F1-F2 space as their stressed counterparts. However, statistical tests permit simple evaluations of the vowels' placement and the effects of stress on it, from the point of view of location in the F1 and F2 planes, and also with regard to formant value variability.

A statistical mixed model was run on these data to learn whether stress does in fact significantly affect the formant values of Romanian vowels. The data used were normalized by speaker; the dependent variables were thus the normalized F1 and F2 values at vowel midpoints. A separate model was run for each formant of each vowel (14 models total); fixed effects were stress and gender, and *word* was included as a random effect. The model found significant effects of stress on F1 for /ʌ/ ($F(1, 16.36)$ = 5.2358, p = .0358) and /i/ ($F(1, 2.116)$ = 25.5765, p = .0329). Significant differences in F2 across stress conditions were found for /e/ ($F(1, 1.786)$ = 33.9512, p = 0.0364) and /ɨ/ ($F(1, 385.9)$ = 5.3523, p = 0.0212). The limited nature of these significant effects across the vowel inventory, and their only marginally-significant p-values, indicate that while stress conditions may be responsible for some variation in formant values, vowel quality in Romanian does not change drastically across stressed and unstressed tokens. This finding provides additional support for the status of /ʌ/ and /ɨ/ as full, non-reduced vowels, since they are affected by stress with the same rate as their front high and mid counterparts /e/ and /i/.

A statistical test for unequal variances (a 2-sided F test) was used on these data to learn whether stress affects the variability of formant values in Romanian vowels. This test compares standard deviations across two samples, in this case normalized values of stressed vs. unstressed vowels (standard deviations of non-normalized data appear below in Table 4.6). If vowel reduction is taking place, or if unstressed vowels have a less-precise acoustic target than stressed vowels, this test should find a)

152

significant differences in the variance of stressed vs. unstressed vowels, and b) that the variance of unstressed vowels is greater than that of unstressed vowels. Normalized-by-speaker data were used; the test was run on each formant, vowel, and gender separately, for a total of 28 separate tests (7 vowels x 2 genders x 2 formants). Effects were equally common on males' and females' data; out of the 28 tests, 10 of them found significant differences in the standard deviations of either F1 or F2 of a particular vowel. The results of these tests are summarized, for females only, in Figure 4.9 and Figure 4.10 below; the presence of an asterisk (*) indicates a significant difference between the standard deviations.
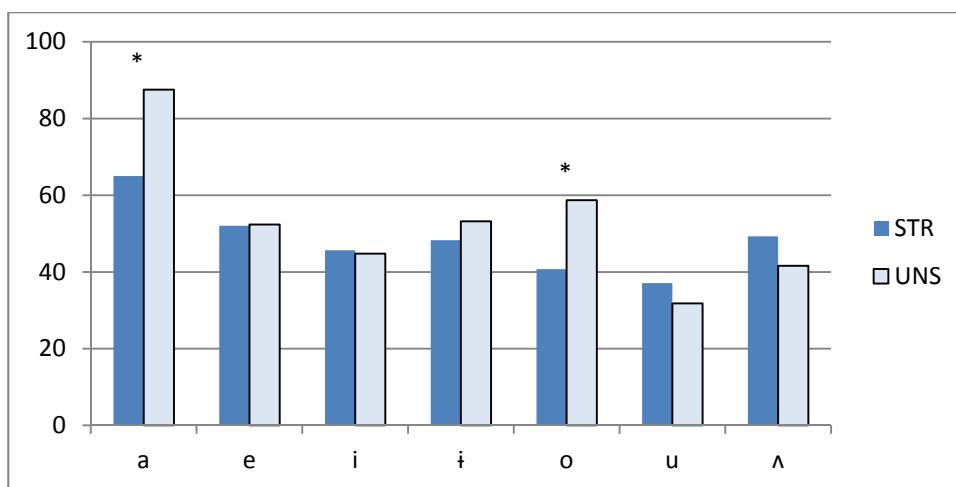
Figure 4.9.   **Standard deviations of F1 in stressed and unstressed Romanian vowels (14 female speakers, normalized data)**

153
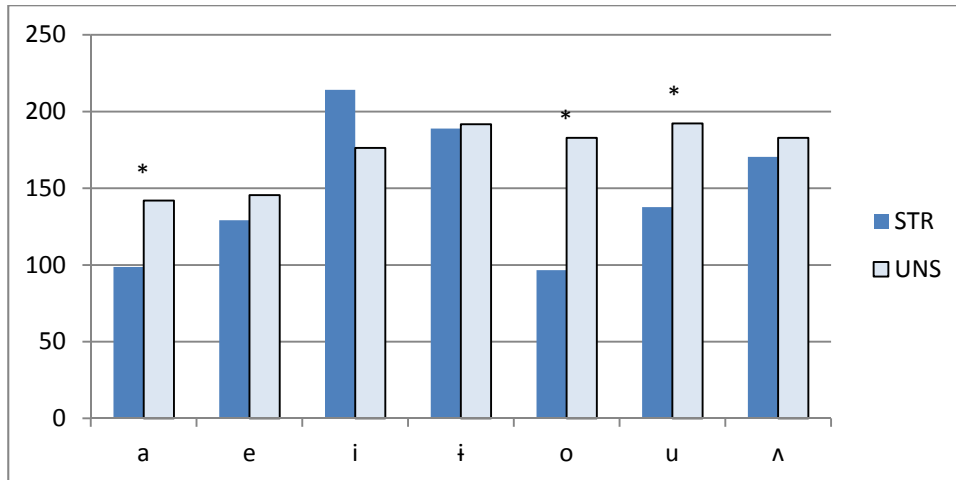
Figure 4.10.   **Standard deviations of F2 in stressed and unstressed**

Romanian vowels (14 female speakers, normalized data)

The fact that only one-third of tests found a significant difference in variances indicates that, overall, the effects of stress on variance are small, with some exceptions (for example /a/ for female speakers). With regard to the relative sizes of the standard deviations, however, we see that in four out of seven vowels (for F1) and six out of seven vowels (for F2), the unstressed condition does have a higher standard deviation than the stressed condition. This indicates a tendency, albeit statistically insignificant, for unstressed vowels to be more variable than stressed vowels. It is again notable that the variance of non-low central vowels /ɨ/ and /ʌ/ does not tend to be more affected by stress than other vowels are. In males' data, there are two significant effects on these vowels: the F1 of /ʌ/ is significantly higher in stressed than in unstressed vowels, and the F1 of /ɨ/ is significantly lower in stressed than unstressed vowels. However, as in the statistical test above that compares vowels' locations in the acoustic space, central vowels are no more likely than peripheral vowels to show differences across stress conditions, providing no evidence that they are reduced or have relaxed phonetic targets.

154

4.6.3. Summarizing the vowel space: Mean formant values

Having examined the Romanian vowel space through non-normalized data points, I now present summaries of the data by compiling mean formant values for each gender, in each stress condition. The next four figures display the Romanian vowel space in terms of each speaker's mean F1 and F2 values for each vowel. The figures are separated by gender and stress: Figure 4.11 show females' stressed vowels, while their unstressed vowels appear in Figure 4.12; Figure 4.13 and Figure 4.14 show the stressed and unstressed mean values, respectively, for male speakers. These results distill those shown above in §4.6.1 and §4.6.2, still reflecting the tight cluster of monophthongs, and the extreme high and front acoustic realization of /i/. These graphs show that this arrangement of vowels in the acoustic space is consistent across speakers, reinforcing the normalized results seen above. The scales on these figures match, demonstrating the considerable difference in acoustic space occupied by speakers of different genders.
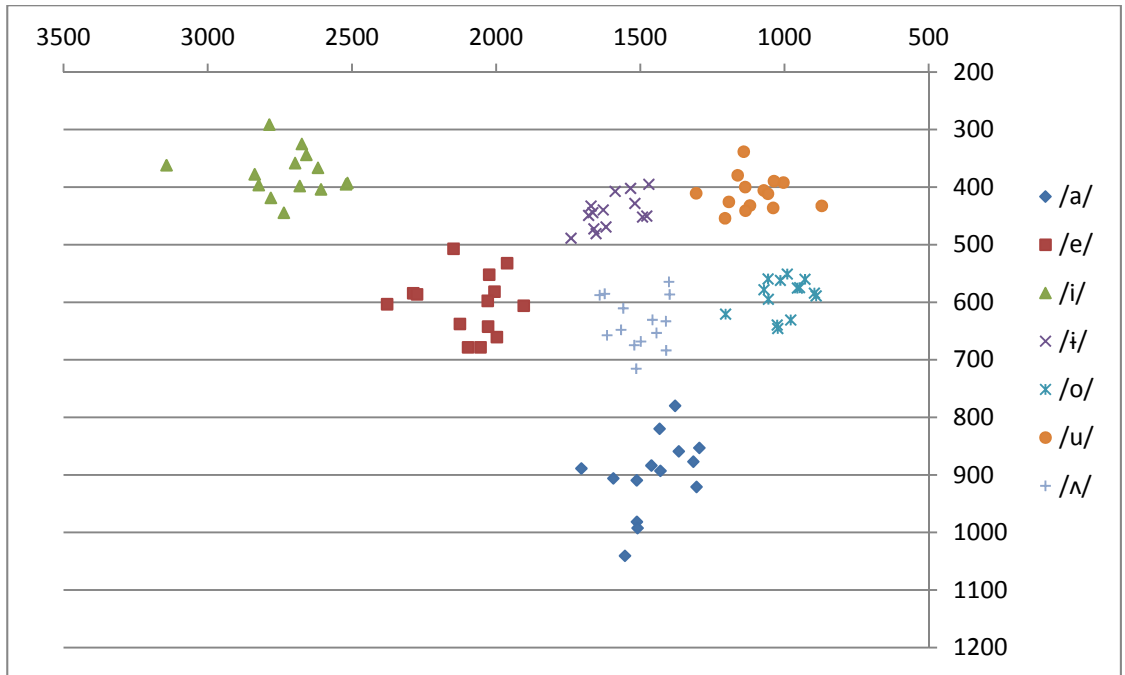
Figure 4.11.   **Mean F1 and F2 values for stressed vowels, female speakers (14 speakers; non-normalized data)**
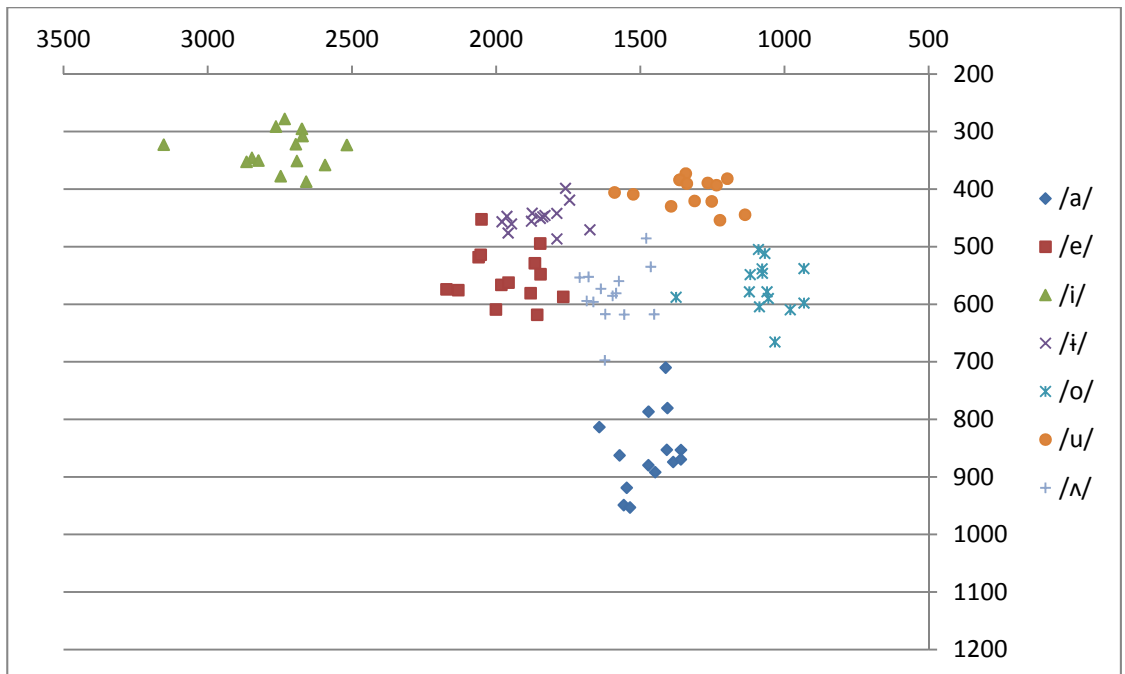
Figure 4.12.   **Mean F1 and F2 values for unstressed vowels, female speakers (14 speakers; non-normalized data)**
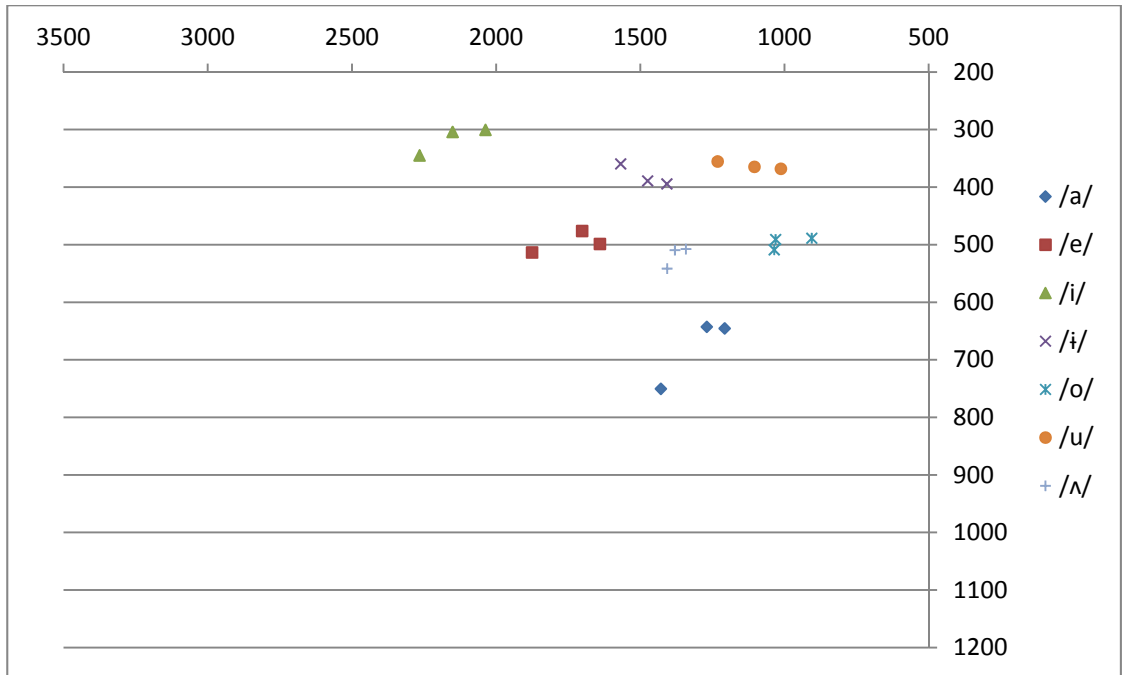
Figure 4.13.　**Mean F1 and F2 values for stressed vowels, male speakers (3 speakers; non-normalized data)**
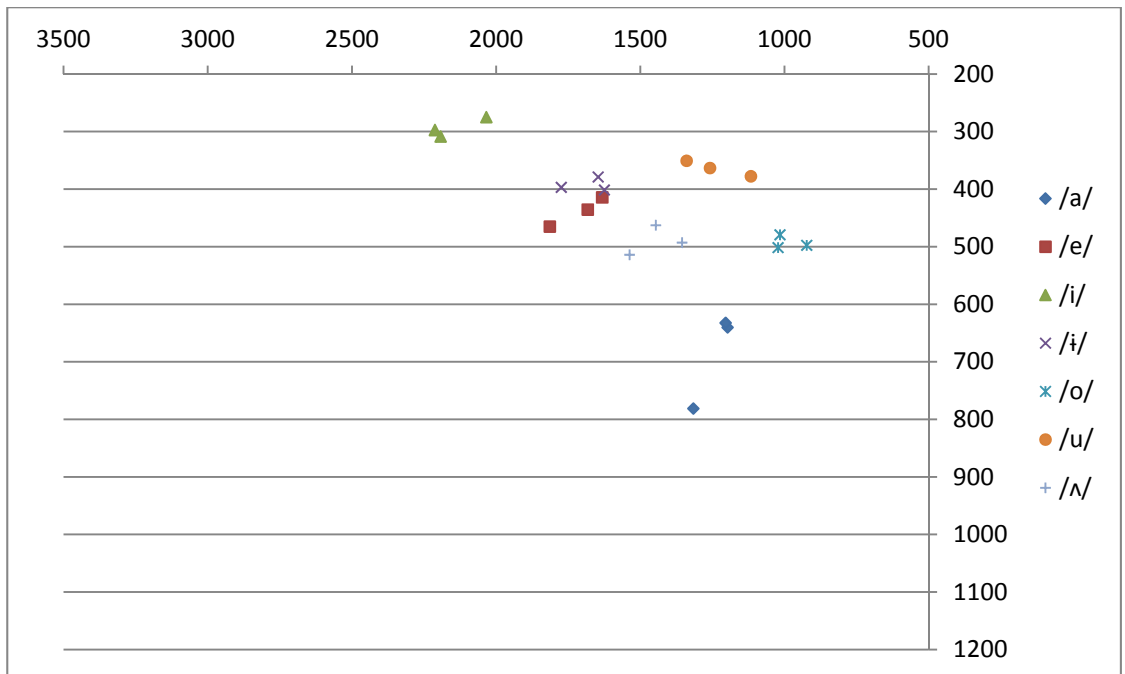
Figure 4.14.　**Mean F1 and F2 values for unstressed vowels, male speakers (3 speakers; non-normalized data)**

157

Further pooling of the non-normalized data is shown below in Table 4.5, which displays mean formant values for female and male speakers, in both the stressed and unstressed condition. This table reflects the data compiled visually in the figures above; namely, that stressed and unstressed vowels have comparable formant values, but that the acoustic range occupied by female speakers is considerably larger than that of male speakers, in both the F1 and F2 dimensions.

Table 4.5.   **Mean frequencies (Hz) for the first and second formants for vowel tokens pooled across speakers, separated by gender and stress condition (14 female speakers; 3 male speakers; non-normalized data)**

			/a/	/e/	/i/	/ɨ/	/o/	/u/	/ʌ/
F	F1	STR	897	603	377	444	591	411	636
		UNS	856	552	333	450	573	406	583
	F2	STR	1463	2095	2720	1600	1003	1106	1503
		UNS	1473	1961	2745	1850	1073	1324	1595
M	F1	STR	679	495	317	381	497	363	519
		UNS	685	438	294	392	494	365	490
	F2	STR	1302	1737	2151	1482	993	1116	1377
		UNS	1239	1710	2149	1683	986	1232	1446

Finally, standard deviations corresponding to the means in Table 4.5 are displayed in Table 4.6, showing that standard deviations as sampled at the vowel midpoint are comparable across stress conditions, with some exceptions such as the F2 of /o/ for both male and female speakers.

Table 4.6.   **Mean standard deviations (Hz) for the first and second**
formants for vowel tokens pooled across speakers, separated by gender
and stress condition (14 female speakers; 3 male speakers; non-
normalized data)

			/a/	/e/	/i/	/ɨ/	/o/	/u/	/ʌ/
F	F1	STR	76	59	48	52	45	37	61
		UNS	96	57	38	53	65	36	54
	F2	STR	133	147	199	199	109	146	184
		UNS	142	148	164	197	185	192	193
M	F1	STR	61	27	28	35	27	13	39
		UNS	75	26	22	47	28	21	30
	F2	STR	111	104	116	162	78	111	148
		UNS	66	82	97	165	124	149	168

Particularly for F2, in both genders' pooled data, unstressed vowels tend to exhibit greater standard deviations than stressed vowels (as evaluated statistically in §4.6.2), indicating that vowels vary along the front-back dimension to a greater degree when unstressed. This increased variation is likely a result of coarticulation with the surrounding consonantal environment, a topic investigated for stressed vowels in Chapter 5. Table 4.6 also shows that, for male speakers in particular, the central vowels /ɨ/ and /ʌ/ do exhibit greater standard deviations (in both formants) than the other vowels. For female speakers, these vowels have very consistent standard deviations across stress contexts, but other vowels (/i/, /o/, /u/) also have high SDs in either stressed or unstressed vowels. Rather than take this as evidence of increased inherent variability of the central vowels, I argue that this increase in variance is due to the larger number of data points for these vowels, and the fact that they appear in a wider number of consonantal contexts in the stimuli and are thus subject to more

159

coarticulatory effects than the peripheral vowels. The statistical analysis in §4.6.2 corroborates this account.

4.6.4.   Interim conclusions: Acoustic characteristics of monophthongs

The data and analyses in this subsection demonstrate several central characteristics of the phonemic monophthongs of Romanian. First, male and female speakers' vowels have strikingly different formant values, as a result of sex-based anatomical differences. Across stress conditions, vowels' formant values are generally consistent; statistical modeling found significant formant differences in very limited contexts. Additionally, the variances of formant values across stress conditions are largely constant; statistical tests of variance found significant differences in less than one-third of cases. Finally, the analyses in this subsection find no evidence that /ɨ/ and /ʌ/ are treated phonetically as reduced vowels, nor do their phonetic realizations appear to overlap in the vowel space to a greater degree than any other vowels. This indicates that despite their marginally contrastive relationship, and their highly conditioned distributions, /ɨ/ and /ʌ/ are synchronically full vowels in the Romanian system.

4.7.   Acoustic characteristics of diphthongs

In addition to the monophthongs of Romanian, I examine the acoustic characteristics of the diphthongs /e̯a/ and /o̯a/. These have been studied acoustically by Rosetti (1959), who focuses on durational characteristics; by Chiţoran (2002b), who includes a small study of the diphthongs' durations and formant transition rates; and by Marin (2005) who investigates the temporal organization of Romanian vowels from the perspective of Articulatory Phonology.

The diphthongs appear in stressed syllables only, and are also phonologically conditioned: /e̯a/ surfaces as [e] before a front vowel, while /o̯a/ appears as [o] when followed by /i/, as in [se̯arʌ] vs. [serʲ] 'evening(s)' and [o̯arʌ] vs. [orʲ] 'hour(s)'. These diphthongs are also heavily used within morphological markers (Chiţoran 2002c; §3.4), or are created as a combination of a stem-final vowel and morphological marker. Their defining acoustic characteristics, as we will see below, are that they clearly have two vowel targets – one peripheral mid vowel, and a second low /a/ target (see also Chiţoran 2002a and Chiţoran & Hualde 2007 for a discussion of diphthongs' acoustic and perceptual characteristics, in comparison to glide-vowel sequences). They are characterized acoustically by one set of formant values at their onset, in the range of either /e/ or /o/ and quickly transition to formant values in the range of /a/ during their steady state portion.

The data analyzed here include a list of 39 Romanian lexical items, and they were collected using methodology described generally in §4.2. The target words are either bi- or trisyllabic, with stress always on the diphthong, which was penultimate in all cases. One stimulus contains a verb phrase, *să scoateţi* 'that you (pl.) move,' in order to place the diphthong in a trisyllabic context with the desired stress conditions.

Efforts were made to control the consonantal environments flanking the diphthong, to avoid liquids and nasals, which often coarticulate with vowels and could affect their formant values; however, a few stimuli place /r/ adjacent to the target segment, and two also contain /n/ next to the diphthong. All stimuli were produced in a frame sentence. The list of words, organized by diphthong and including their phonemic transcription, appears in Table 4.7 below. In this list, the sequence [e̯a] or [o̯a] in the transcription always represents a diphthong, and stress always falls on the syllable containing that diphthong.

161

Table 4.7.   **Romanian diphthongs: Lexical item stimuli**

	Word (transcription) *Target vowel is **bold**.*	Word (orthography)	Gloss
1	not**ea**zʌ	notează	note (3 sg.)
2	t**ea**pʌ	teapă	stamp, kind
3	t**ea**tru	teatru	theater
4	sos**ea**skʌ	sosească	arrive (3 sg. subj.)
5	v**ea**kurʲ	veacuri	century (pl.)
6	g**ea**bʌ	gheabă	type of mushroom
7	gʌs**ea**skʌ	găsească	find (3 sg. subj.)
8	g**ea**tʌ	gheată	boot
9	aʃt**ea**ptʌ	așteaptă	wait (3 sg. subj.)
10	veg**ea**zʌ	veghează	watch (3 sg./pl.)
11	vorb**ea**skʌ	vorbească	speak (3 sg. subj.)
12	tʃit**ea**skʌ	citească	read (3 sg. subj.)
13	g**ea**tsʌ	gheață	ice
14	ts**ea**pʌ	țeapă	splinter, spike
15	lips**ea**skʌ	lipsească	lack (3 sg. subj.)
16	k**oa**ptʌ	coaptă	cooked (f. sg.)
17	k**oa**tʃe	coace	cook (inf.)
18	k**oa**psʌ	coapsă	thigh
19	k**oa**dʌ	coadă	tail
20	pod**oa**bʌ	podoabă	ornament
21	p**oa**tʌ	poată	be able (3 sg. subj.)
22	k**oa**sʌ	coasă	scythe
23	vɨnt**oa**sʌ	vântoasă	windy
24	k**oa**stʌ	coastă	rib
25	k**oa**se	coase	sew (inf.)
26	t**oa**tʌ	toată	all (f. sg.)
27	sʌsk**oa**tetsʲ	să scoateți	that you (pl.) move
28	ɨn:**oa**de	înnoade	knot (3 subj.)
29	but**oa**ne	butoane	button (pl.)
30	p**oa**te	poate	be able (3 sg.)
31	ɨnt**oa**rtʃe	întoarce	return (3 sg.)
32	ɨnk**oa**tʃe	încoace	near
33	t**oa**te	toate	all (f. pl.)
34	d**oa**gʌ	doagă	stave
35	mʌs**oa**re	măsoare	measure (3 sg. subj.)
36	t**oa**kʌ	toacă	vesper
37	prov**oa**tʃe	provoace	provoke (3 sg. subj.)
38	sk**oa**te	scoate	move (3 sg.)
39	plet**oa**sʌ	pletoasă	long-haired (f. sg.)

The words shown in Table 4.7 were all recorded, either at the Cornell phonetics lab or in a quiet environment in Cluj-Napoca, Romania, with native speakers of Romanian. All participants repeated this list three times in randomized order; the target vowels were segmented, and their formant values (F1, F2, F3) extracted at nine intervals from 10% through 90% of the diphthong's duration, giving snapshots of the diphthongs' formant trajectories over time.

The analysis in Figure 4.15 shows the diphthongs in terms of their transition from one vowel sound to the next and in relation to stressed monophthongs. To make this figure, formant values were compiled to calculate mean F1 and F2 values for the initial (10%) and near-final (70%) measurements taken in this data set. An endpoint of 70%, rather than the last measurement taken at 90% of duration, was chosen for these figures because it is a more accurate depiction of the diphthong's characteristics during its steady state. At 80-90% of its duration, the diphthong is already in transition to the following consonant, and F1 values especially have begun to change.
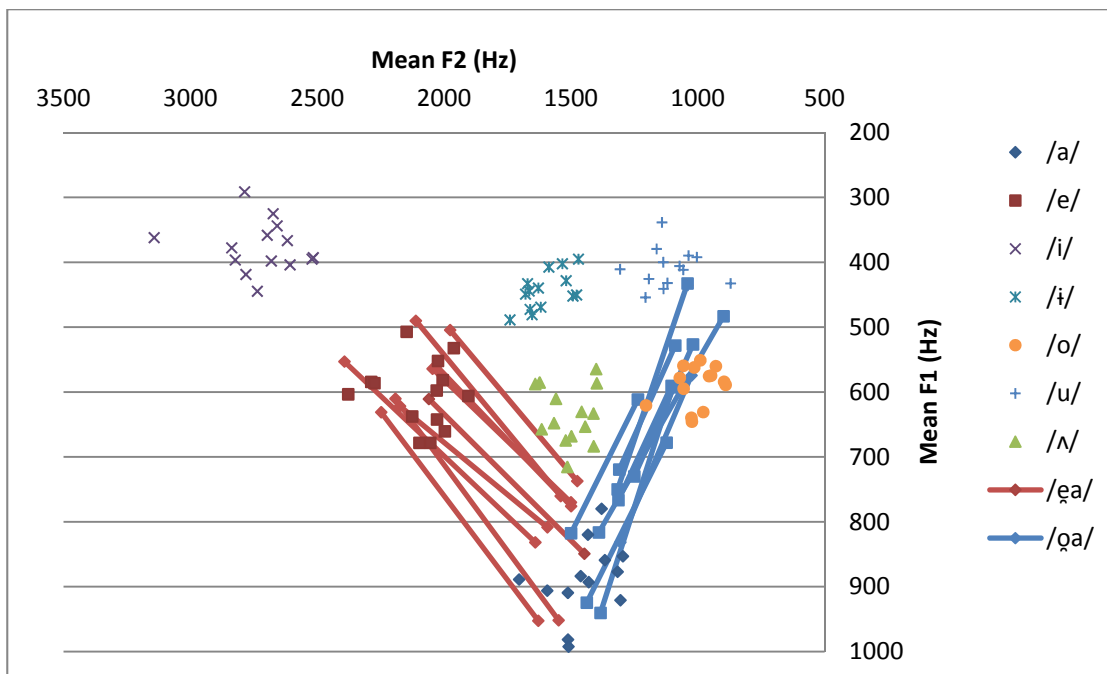
Figure 4.15. **Mean F1 and F2 values for all stressed vowels (14 female speakers; non-normalized data)**

For /ĕa/, the 10% measurement places the beginning of the diphthong near tokens of /e/, and its 70% endpoints fall in the region of /a/. For /ŏa/, the 10% measurement approximates the formant values of an /o/, and the 70% measurement, like that of /ĕa/, is near that of /a/. Thus in the case of /ĕa/, we see that F1 rises during the course of the diphthong, but F2 falls; and in /ŏa/, F1 rises along with F2: both diphthongs, acoustically as well as phonologically, lower in vowel height and also move toward the center of the vowel space. For the female speakers' data shown here, both /ĕa/ and /ŏa/ begin with an F1 of approximately 600 Hz, ending near 850 Hz; in the F2 dimension, /ĕa/ moves from approximately 2100 Hz to 1500 Hz, while /ŏa/ begins near 1100 Hz and ends at roughly 1400 Hz.

A second pair of figures illustrating the basic acoustic vowel space of Romanian shows the mean F1-F2 values for one female speaker (Figure 4.16) and one

male speaker (Figure 4.17). The arrangement of vowels in each of these figures is representative of the patterns of other speakers recorded in this study, especially regarding the relatively close spacing of /a, e, ʌ, o, ɨ, u/ in contrast to /i/; and the comparable F2 values for the central vowels /a, ʌ, ɨ/. For some speakers, /i/ is even further front and higher, with respect to other vowels, than in these figures. These figures also include beginning- and endpoints for the diphthongs, averaged across tokens and measured at 10% and 70% of vowel duration, respectively. These figures pool across data from stressed vowels only.
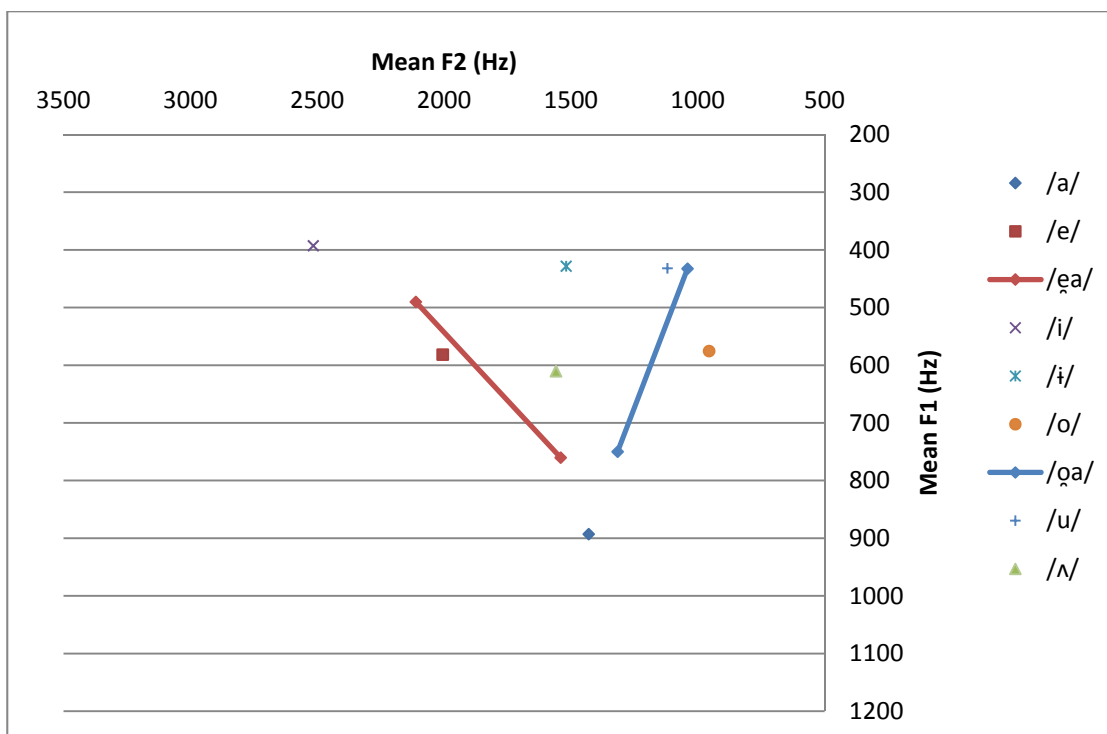
Figure 4.16.   **Speaker F5: Mean F1 – F2 values for all stressed vowels, including diphthongs**
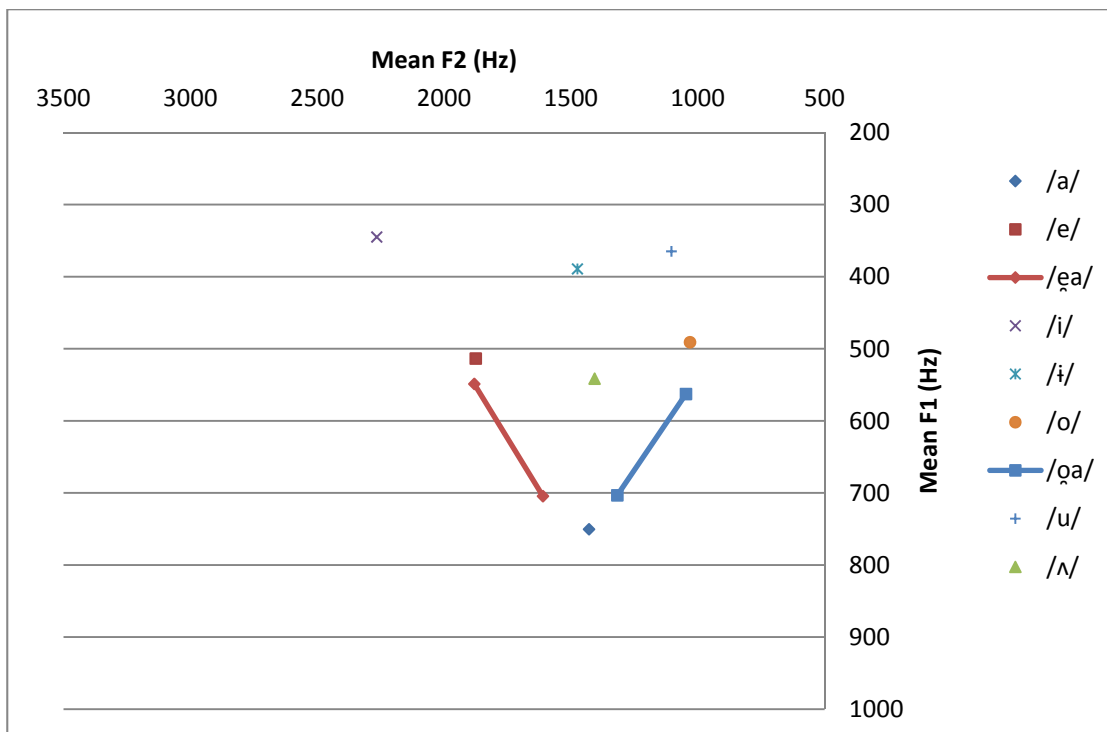
Figure 4.17.   **Speaker M2: Mean F1 – F2 values for all stressed vowels, including diphthongs**

Clear evidence that these Romanian diphthongs have two separate targets appears in Figure 4.18 below, which shows a normalized and averaged set of formant trajectories for F1, F2 and F3, in both /e̯a/ and /o̯a/, for female speakers of Romanian. This figure was created by first normalizing the data for each speaker, by subtracting from each formant-specific data point the mean value for that formant (i.e. F1) for that speaker (i.e. Speaker F5). This was done using a single speaker-specific mean value across all nine sampling points, preserving the curves seen in the figure. Since normalization was performed on a by-formant basis, the resulting averaged formant trajectories were no longer separated by hundreds of Hertz, but were all centered around a mean value of zero; for the purposes of graphing, therefore, a value was added to each normalized data point. This value was a mean value, calculated across

166

all female speakers, for each formant; this technique had the effect of "boosting" F2 and F3 values above those of F1 without re-introducing speaker-specific effects.

The vertical axis on this figure measures Hertz, which in this case are normalized; and along the horizontal axis, data points correspond to /e̯a/ tokens (on the left) and /o̯a/ tokens (on the right). Each diphthong is divided into nine points, corresponding to percentages of duration during the course of the vowel (beginning at 10% and ending at 90%); thus each point on the graph represents a value found by averaging across all normalized values of, for example, formant measurements of /e̯a/ tokens taken at 10% of their duration.

In Figure 4.18, for /e̯a/, F1 begins low, and F2 high, as in an articulation of /e/; they then converge over the vowel's time course, arriving at F2 formant values appropriate for /a/ approximately 60% of the way through the vowel, and remaining steady until vowel offset. The trajectory of /o̯a/, which begins with low F1 and also low F2 (as in /o/), also converges on an articulation of /a/; however, there is no visible steady state, particularly in F2, for that diphthong. The F1 trajectories of /e̯a/ and /o̯a/ are similar. Both diphthongs have comparable F3 values, although the onset of /e̯a/'s F3 trajectory is relatively higher, which is presumably a global effect resulting from high F2 values. These data reinforce the observation that /e̯a/ and /o̯a/ in Romanian are true diphthongs composed of two separate vowel targets.
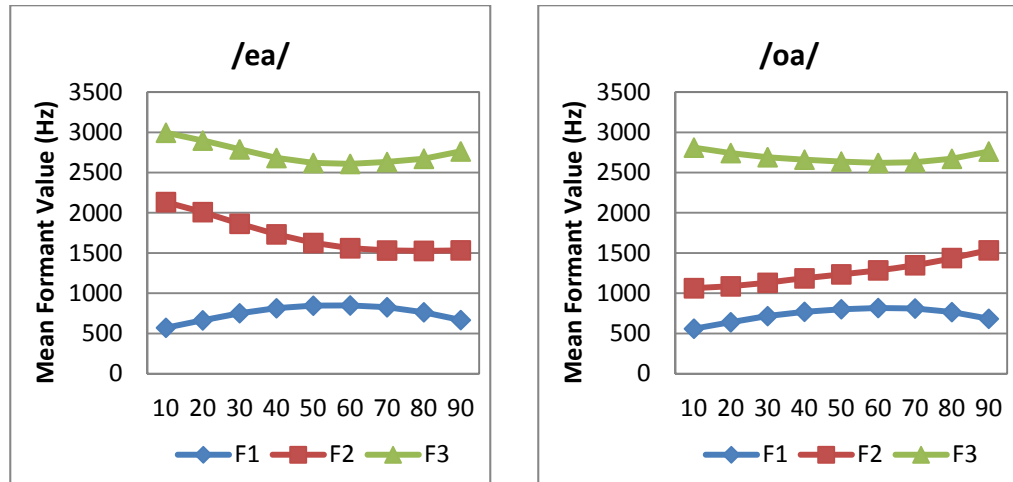
Figure 4.18.　**Formant trajectories in diphthongs produced by female Romanian speakers, normalized across speakers (with overall formant mean re-added), averaged across each sampling point**

It should be noted that the diphthongs are not glide-vowel sequences. They behave phonologically as a single unit, and and there is no weight-based evidence that they are distinct from monomoraic vowels; they can appear in syllables with complex onsets, while glide-vowel sequences cannot (Chiţoran 2002c). Other representations may be rejected on the basis of phonological evidence. The two portions of the diphthong are argued to belong to a single nucleus because diphthongs alternate, in their entirety, with monophthongal vowels; and there is no evidence from phonological weight, for example restrictions on the diphthongs' appearance in closed syllables, that the diphthongs are bimoraic (Chiţoran 2002c:sec. 3). Modeled in an Articulatory Phonology framework, the diphthongs are argued to be composed of two synchronously-coordinated vowel gestures (Marin 2005; Marin & Goldstein 2012).

4.8.   **Duration of vowels**

     To bolster understanding of the acoustics of Romanian vowels, I next consider their duration, with respect to different contexts and variables known to affect duration. Few resources are available on the duration of Romanian vowels in particular, although some recent studies have examined the role of duration as a cue to other linguistic information (Chiţoran & Hualde 2007). Rosetti (1955; 1959) compares the durations of diphthongs (/e̯a/, /o̯a/) to glide-vowel sequences (e.g. [ja], [wa]), finding roughly equivalent total durations, although the inner timing of each unit is different; these results are largely corrobotated by Ulivi (1975). Chiţoran (2002a) also analyzes the durations of diphthongs in comparison to glide-vowel sequences, offering a statistically-analyzed corpus of data; however, the focus of the present study is monophthongs, which we expect to have different durational properties. Manolescu et al. (2009) examine the phonetic properties of contrastive focus in Romanian, and find that in an utterance containing contrastive focus, the focused element exhibits greater segmental durations than those that precede and follow it. Their data include the vowels /a/, /i/ and /e/, whose durations are compared statistically; however, since the topic of their study is prosodic focus, our results are comparable only under limited circumstances in which prosodic conditions match. Frunza (2011) offers raw durational data on vocalic elements in sequences of diphthongs, triphthongs, and hiatus environments, but her methodology is unclear. Given the dearth of available data on duration in Romanian, the descriptive data presented here add considerably to our knowledge of the topic.

     The data presented here can most straightforwardly be compared to results from other more thoroughly-investigated languages, such as English, which allows us to evaluate the degree to which Romanian vowels follow cross-linguistic durational trends. For a basic descriptive analysis of the durational properties of Romanian

169

vowels, we are interested in questions such as the following: Does vowel duration vary systematically by phonological height or openness, as shown for English by e.g. Peterson and Lehiste (1960)? Are vowels shorter in closed than open syllables? Do vowels undergo final lengthening? How does the number of syllables in a word affect vowel duration? What is the proportional duration difference between stressed and unstressed syllables, and how does that interact with syllable structure, syllable count, and place in the word?

The framework used by Crystal and House (1988) to display duration data from a corpus of spontaneous American English speech is useful for this study as well. The authors examine the effects of stress, vowel length, syllable structure and other prosodic factors on vowel duration, and find that core generalizations about duration are possible even when not all these factors are strictly controlled. For example, stressed vowels tend to be longer than short vowels, and long vowels are longer than short vowels. Their study also finds that standard deviations increase with the mean duration of a group of vowels, and that stress-based variations are greater than tempo-based ones (Crystal & House 1988:267). This finding suggests that useful generalizations can be gleaned from durations even when speech rate is not strictly controlled, like in the data presented here.

A general finding of durational studies in English is the inherent durational differences between long and short vowels. While Romanian vowels do not fall into these categories, they do fall into three phonological heights, and it is along this axis that I separate the durational data presented here. A general expectation regarding the relationship between vowel height and duration is that low vowels are of longer duration than mid vowels, which in turn are longer than high vowels (Lehiste 1970). Additionally, the data are separated by gender, because a t-test revealed a significant effect of that factor on vowel duration. Within each vowel height category, the data

are further separated by stress (stressed or unstressed); and into subcategories based on the vowel's position in the word: final, nonfinal (including both penultimate and antepenultimate vowels), or "mono" for monosyllabic words. Finally, each token was categorized based on syllabic structure, and labeled according to the presence or absence of a syllable coda, either before a word-internal syllable boundary (marked by "V."), or a word boundary (marked by "V#").

Durational data from female Romanian speakers appears in Table 4.8; male speakers' data is summarized in Table 4.9. The tables are arranged vertically by vowel height, from high to low; within each height, rows include mean duration and its standard deviation (both in milliseconds), as well as the number of tokens averaged for that category (N), shown in *italics*. Note that since the words in this study were collected to focus on characteristics of vowel quality, not duration, the data set is not balanced; numbers of tokens vary widely across cells, and some cells contain no data. These gaps are accidental, not due to phonological restrictions.

The columns in each table show prosodic information: the data are divided between stressed and unstressed vowels, and within each category are monosyllables (for stressed vowels), final vowels in polysyllabic words, and nonfinal vowels. Those categories are further divided by syllable structure, either word-final (V#), word-final but followed by a consonant (VC#), or non-final, with or without a coda consonant (V., VC.).

Table 4.8.   **Vowel durations: Female speakers**

Female speakers	Stressed vowels						Unstressed vowels			
Syllable position	MONO		FINAL		NONFINAL		FINAL		NONFINAL	
Syllable structure	V#	VC#	V#	VC#	V.	VC.	V#	VC#	V.	VC.
High vowels										
Dur (ms)	158	125	149	94	103	88			58	57
SD (ms)	49	46	49	24	24	34			16	17
N	*208*	*170*	*85*	*85*	*292*	*87*			*252*	*84*
Mid vowels										
Dur (ms)	182	147		133	118	95	103	95	72	
SD (ms)	47	39		26	19	13	27	17	12	
N	*210*	*251*		*110*	*198*	*43*	*73*	*85*	*171*	
Low vowels										
Dur (ms)			173		153				94	
SD (ms)			42		19				23	
N			*40*		*47*				*80*	

In the data from female speakers in Table 4.8, I first examine data across stress conditions. Two main generalizations hold: first, that stressed vowels are longer than unstressed vowels (effect of stress on duration: $F(1, 2570) = 1115.680$; $p < .0001$), and second, that low vowels are longer than mid vowels, which are longer than high vowels (effect of height on duration: $F(2, 2569) = 74.2897$; $p < .0001$). Among stressed vowels, final vowels are longer, at all heights, than nonfinal vowels ($F(2, 1823) = 220.7438$, $p < .0001$), although it appears that the effects of height are greater than those of syllable position: stressed low vowels in nonfinal position are still longer than stressed high vowels in final position. Within mid and high vowels, vowels in monosyllabic forms (**MONO**) are longer than those in polysyllabic words (**FINAL**, **NONFINAL**); a Student's T-test shows that in fact, mean durations are significantly different across all three syllable positions, for both vowel heights ($p < .0001$ in all cases). Among unstressed vowels, in the final position there is data only for /ʌ/; these tokens are shorter than all stressed mid vowels. The nonfinal unstressed vowels show

a three-way durational division based on height, as holds elsewhere in the data; the means of the three heights are significantly different, as verified by a Student's T-test ($p < .0001$).

Turning to the effects of syllable structure, comparisons become sparser due to the nature of the data set. However, where comparisons are possible within a particular stress condition, syllable position and vowel height (i.e. for stressed final high vowels, unstressed final mid vowels, etc.), vowels in open syllables are longer than those in closed syllables (general effect of syllable structure on duration: $F(3, 1822) = 29.9960$, $p < .0001$). This systematic pattern is consistent with the cross-linguistically common phenomenon of Closed Syllable Vowel Shortening, which is argued to be a cue to syllabification (Maddieson 1985).

The difference in length across syllable types holds for all comparisons except within nonfinal unstressed vowels, for which only high vowels appear in both open and closed syllables. Across both syllable types in this subset, the mean durations and standard deviations are nearly equivalent (although the sample sizes are quite different): 58ms (16ms SD) for open syllables, and 57ms (17ms SD) for closed syllables. Within this subset, there is no significant difference in means: $F(1, 334) = 97.83$, $p = .6320$). These durations are already very short; they measure less than half the duration of high vowels in stressed, final, open syllables. Thus this cross-contextual equivalency likely results from an incompressibility effect, which is a principle of durational modeling under which, although segments shorten in some contexts and lengthen in others, they have a minimum duration beyond which they cannot shorten (Klatt 1973).

Table 4.9.   **Vowel durations: Male speakers**

Male speakers	Stressed vowels						Unstressed vowels			
Syllable position	MONO		FINAL		NONFINAL		FINAL		NONFINAL	
Syllable structure	V#	VC#	V#	VC#	V.	VC.	V#	VC#	V.	VC.
High vowels										
Dur (ms)	129	91	124	67	90	76			57	50
SD (ms)	36	33	49	16	20	30			16	14
N	*45*	*36*	*18*	*18*	*64*	*18*			*55*	*18*
Mid vowels										
Dur (ms)	136	109		98	103	82		82	76	
SD (ms)	39	29		18	13	12		13	18	
N	*50*	*56*		*24*	*44*	*9*		*18*	*35*	
Low vowels										
Dur (ms)			147		127				95	
SD (ms)			41		9				19	
N			*9*		*9*				*18*	

Among male speakers' data in Table 4.9, we find evidence for the same generalizations as for female speakers. Male speakers' stressed vowels tend to be shorter than those of female speakers; for example, for low vowels the average across all stressed vowels is 137ms (31ms SD), compared to 162ms (33ms SD) in Table 4.8. Across unstressed vowels, however, males' vowel durations are comparable to those of female speakers.

In analyses of vowel duration in English, a frequent focus of analysis are durational differences triggered by post-vocalic consonants. House and Fairbanks (1953) consider English vowel durations as a function of consonantal contexts, in closed syllables only; Peterson and Lehiste (1960) reinforce the continuum of durational effects with their data, demonstrating that all else being equal, durations increase from shortest before a voiceless stop, then a voiceless fricative; longer durations appear before a voiced stop, and the longest before a voiced fricative. However, for spontaneous speech data, Crystal and House (1988) examine the effects

174

of stress and vowel length on duration, and show that even when segmental context is not taken into account, generalizations about duration are still possible.

In this data set, it is difficult to evaluate the durational effects of context, such as the voicing or manner of articulation of segments following the target vowel. This was not the study's focus, and the data set was not designed for this purpose. Outside of a few crucial minimal pairs, attempts were made to place target vowels in stop-stop (at least, obstruent-obstruent) environments to reduce coarticulatory effects. For this reason, the place and manner of articulation of consonants are not considered here.

To summarize briefly, the new, statistically-compared durational data presented here do not show any unexpected results based on what is known about vowel duration from other languages; for Romanian in particular, this study represents a significant addition to our body of phonetic knowledge. There are clear effects of vowel height, stress, syllable position and syllable structure on duration, such that the longest vowels are those in open monosyllables (for mid vowels) or final syllables (for /a/, the low vowel). The shortest vowels are those in unstressed, nonfinal syllables, and for those vowels there is no additional shortening effect due to the presence of a coda consonant; this provides evidence for a minimum inherent duration and vowel incompressibility.

These data provide a set of expectations for a certain prosodic position (i.e. with main phrasal stress in the frame *Spune X de trei ori*), with statistical comparisons and sample sizes previously unavailable for the full range of Romanian monophthongs. These data do not, however, provide information on how duration is used in Romanian; in English, for instance, perceptual experiments have demonstrated the range of linguistic phenomena cued by duration, such as consonant voicing, emphasis, vowel reduction, and inherent vowel length (Klatt 1976). Based on these data, a small amount of conjecture is possible: these data indicate large durational

differences across contexts, particularly across stress conditions. For example, for female speakers, there is a difference of nearly 70ms between the mean durations of all stressed and unstressed low vowels. It has been shown (Klatt 1976) that the minimum just-noticeable difference for duration is approximately 25ms; many comparisons within the Romanian data exceed this threshold, so I hypothesize that the durational differences are perceptible, making them available as linguistic cues. Additional research, including perceptual study, is necessary to pinpoint the role of duration as a cue in Romanian.

4.9.   Perceptual studies: Pilots and future directions

To begin to investigate the relationship between the acoustics, phonological status, and perception of vowels in Romanian, I conducted two pilot studies on this topic. Both studies focused on four Romanian vowels: /i/, /e/, /ɨ/, /ʌ/. As is discussed in Chapter 2 and Chapter 3, the phonological relationship between the two central vowels /ɨ/ and /ʌ/ is one of marginal contrastiveness, in which the vowels arose as allophones, but are now considered separate phonemes, although few minimal pairs separate them and they remain largely in complementary distribution. These pilot experiments ask what the consequences of marginal contrastiveness are for perception, by comparing this pair of vowels with a pair of robustly-contrastive, uncontroversially phonemic vowels, namely their front-vowel counterparts /i/ and /e/. The studies hypothesize that if marginal contrastiveness is relevant for perception (measured via vowel identification), then the rate of confusion between /ʌ/ and /ɨ/ should be higher than within any other given pair of vowels.

In both pilot studies, listeners were presented with stimuli from an informal phonotactic paradigm in which the consonantal environments surrounding the stressed vowel of interest matched across vowel types; for example, the set included four

176

words of the form /#mVr/. Participants heard each stimulus in a truncated form created using techniques similar for gating experiments (Lahiri & Marslen-Wilson 1991). Stimuli were truncated at the end of the consonant-vowel transition; after the first third of the vowel; after two thirds of the vowel; and at the vowel's end, generating four stimuli per target word.[35] Participants were instructed to identify the last vowel they heard in each stimulus; confidence ratings were also gathered.

The first pilot study contained two sets of words: first, a "basic" condition, in which all four vowels were included and the phonological environments surrounding each vowel matched; in the second condition only /ɨ/ and /ʌ/ were tested, and each vowel appeared before either a nasal /n/ or a non-nasal consonant. The second condition was intended to test the sub-hypothesis that accurate identification of /ʌ/ and /ɨ/ should be dependent on the surrounding consonants, in ways that reflect the environments in which each vowel was originally conditioned. This experiment was run with 39 participants in Cluj-Napoca, Romania; the results generally indicated that /ʌ/ was perceived with less success than any other vowel. The high rate of confusion may well be due to some measure of inconsistency in how we designed the nasal condition stimuli. The results of the first pilot study are summarized in a confusion matrix (Miller & Nicely 1955) in Table 4.10; the left columns in this table show the actual vowel quality, and the rows display how often a stimulus was identified as each possible response. Percentages indicate accuracy, and shading correlates with the percentages (darker = higher accuracy). What this table does not show is that the results in the pre-nasal condition in particular depend heavily on gate duration.

---

[35] Greater detail about experimental methodology is provided in Appendix C.

Table 4.10.   **Pilot study 1: Accuracy by word and experimental**

condition, pooled by gate and listener

BASIC CONDITION		Response			
Stimulus	Vowel	i	ɨ	ʌ	e
/mire/	i	98.3%	0.1%	0.0%	1.6%
/mɨrɨj/	ɨ	0.9%	98.6%	0.5%	0.0%
/mʌrul/	ʌ	0.4%	24.3%	75.4%	0.0%
/mere/	e	0.0%	0.3%	0.1%	99.6%
NASAL CONDITION		i	ɨ	ʌ	e
/gɨt/	ɨ	0.0%	98.3%	1.8%	0.0%
/gɨnd/	ɨ	0.0%	93.9%	6.1%	0.0%
/tigʌj/	ʌ	13.3%	13.0%	73.8%	0.0%
/gɨngʌni/	ʌ	4.6%	11.3%	84.1%	0.0%

Due to my suspicions that identification rates for /ʌ/ dropped in the nasal condition because their structure did not match that of other stimuli, the experiment was re-designed as an expanded version of the "basic" condition, and run with seven native Romanian participants at Cornell University. In this study, each vowel was presented in four different phonological environments, meaning that 16 words were used (details appear in Appendix C), resulting in twice as many stimuli as in the first pilot study. Expanding the set of phonological environments (i.e. to include more than the /#mVr/ frame) allowed me to test whether asymmetries in vowel perception are consistent across phonological environments, to exclude the possibility that the original low identification rates of /ʌ/ were linked to a particular environment. Indeed, results demonstrated considerable asymmetry in identification rates: /i/ was identified correctly nearly 100% of the time, while /e/ was correctly identified in 92% of cases, /ɨ/ in 89.2%, and /ʌ/ in only 86.7% of cases (9.7% of /ʌ/ stimuli were misidentified as /ɨ/). In Table 4.11 below, results are again presented as confusion matrices, but are divided by stimulus length (a factor which affects accuracy, especially for /ʌ/), and

pooled across words. In the second pilot study, confidence ratings were found to correlate with overall accuracy: participants were less confident in stimuli that were likely to be misidentified.

Table 4.11.   **Pilot study 2: Overall accuracy by gate; pooled by listener and word**

TRANS	Response					1/3	Response			
Vowel	/i/	/ɨ/	/ʌ/	/e/		Vowel	/i/	/ɨ/	/ʌ/	/e/
i	99.6%	0.0%	0.0%	0.4%		i	98.8%	0.4%	0.0%	0.8%
ɨ	0.0%	89.4%	4.5%	6.1%		ɨ	0.8%	89.0%	4.1%	6.1%
ʌ	0.0%	14.7%	82.0%	3.3%		ʌ	0.0%	12.2%	82.9%	4.9%
e	0.4%	5.3%	3.7%	90.6%		e	0.0%	3.7%	4.5%	91.8%

2/3	Response					FULL	Response			
Vowel	/i/	/ɨ/	/ʌ/	/e/		Vowel	/i/	/ɨ/	/ʌ/	/e/
i	99.1%	0.4%	0.0%	0.4%		i	99.6%	0.0%	0.0%	0.4%
ɨ	0.0%	89.0%	4.1%	6.9%		ɨ	0.0%	89.4%	2.0%	8.6%
ʌ	0.0%	6.1%	91.0%	2.9%		ʌ	0.4%	5.7%	91.0%	2.9%
e	0.0%	2.5%	3.7%	93.9%		e	0.0%	2.9%	5.3%	91.8%

Despite the relative consistency apparent in Table 4.11, further investigation showed that accuracy results differed widely across phonological contexts. This suggests that lexical frequency effects may be relevant for accuracy; however, Romanian lexical frequency data are not currently available at the levels necessary to dissect these results. Nevertheless, there is a consistent result across both pilot studies, namely that /ʌ/ is identified with a lesser rate of accuracy, and it is most likely to be confused with its marginally contrastive partner /ɨ/. This indicates that future studies, with further controls and larger numbers of participants, could shed light on the role of marginal contrast for perception. Additionally, for Romanian, a more complex design could prove very interesting, to investigate more precisely the role of phonological context in vowel identification. For a study of this type, I predict that since /ɨ/ was historically phonologically conditioned before nasal consonants (and still appears

179

there in 75% of cases), listeners would preferentially choose /ɨ/ over /ʌ/ in a prenasal environment. Experimentation of this type can pick apart the interaction between marginal contrast and phonological environment as relevant for vowel perception.

4.10.   Conclusions: Basic acoustics of Romanian vowels

This chapter has presented results of studies showcasing data on Romanian vowels, focusing on monophthongs to emphasize the vowels' location in acoustic space, particularly with respect to their first and second formants and relative to one another. Taken together, some major points emerge from the results: stress conditions have little effect on the formant structure of Romanian vowels, although they have large effects on duration. Additionally, the acoustic characteristics of central vowels /ɨ/ and /ʌ/ are equivalent to those of peripheral vowels, in terms of variability, duration, and acoustic overlap. This indicates that the central vowels are not reduced, or more susceptible to coarticulation than other monophthongs: they are full vowels. The results also support the transcription of the mid central vowel as /ʌ/ rather than /ə/, which could imply a reduced vowel. Whereas in English, the phenomena of vowel centralization, shortening and laxing go hand in hand, that is not the case in Romanian. Both the central vowels undergo shortening, but that is independent of any vowel quality changes and occurs along the same lines as shortening of the peripheral vowels.

This chapter also shows new data on the diphthongs /e̯a/ and /o̯a/, demonstrating that acoustically they have two targets, which match /e/ and /o/ (respectively) at the beginning of the diphthong before quickly transitioning to /a/. These results support the transcription of the diphthongs as a combination of mid and low vowels.

The data show that among monophthongs, /i/ has much more extreme formant values than the other vowels, placing it very high and very front in the acoustic space, such that the acoustic vowel space of Romanian is asymmetrical. In Chapter 5 I present evidence that /i/ exerts considerable coarticulatory pull on other vowels, and that consonants also trigger significant patterns of coarticulation. These findings come from controlled nonce-word studies, which are motivated by further analysis of the data presented in this chapter.

Additionally, this chapter provides new, statistically-validated data on the duration of vowels in Romanian, as compared across stress conditions, syllable position, syllable structure and vowel height. The findings of the duration analysis are consistent with expectations based on research into vowel duration in English, a language whose vowel durations are much better studied.

Finally, this chapter briefly describes two pilot studies into the perception of vowels in Romanian, which indicate that marginal contrastiveness may play a role in listeners' ability to identify a vowel. In both pilot studies, the mid central vowel /ʌ/ was identified with lower accuracy than other vowels, and when misidentified, it was most often mistaken for its high central counterpart /ɨ/.

CHAPTER 5: COARTICULATION IN ROMANIAN AND ITALIAN

5.1. Introduction

This chapter presents an investigation into possible links between synchronic phonological processes and the phonetics of vowels. It is a systematic cross-linguistic study which compares the effects of consonant-vowel coarticulation and vowel-vowel coarticulation, in both carry-over and anticipatory environments, onto stressed vowels. The study compares Italian and Romanian, and in addition to comparing different coarticulatory environments it also tests for differences in coarticulatory patterns across vowel qualities. A central goal of the study is to quantify vowels' characteristics in a context-specific way, particularly by comparing results across contexts to gauge the extent of the relationship between vowel acoustics and coarticulatory context.

The experiment described here is prefaced with data from a pilot study that finds evidence of segmental coarticulation under the following conditions: a) when a target vowel is followed by an underlying /i/; b) when a target vowel is preceded by a labial. These pilot results lead to an in-depth, controlled examination of the acoustics of coarticulation in Romanian, with a comparison to standard Italian, which differs from Romanian in both its vowel inventory and the fact that it does not exhibit phonological metaphony. To my knowledge, this is the first phonetic study of coarticulation in Romanian vowels.

For reference, the vowel systems of Romanian and Italian appear in Table 5.1, arranged by height and backness.

Table 5.1. **Romanian and Italian vowel charts**

Romanian		
/i/	/ɨ/	/u/
/e/	/ʌ/	/o/
/ẹa/	/a/	/ọa/

Italian	
/i/	/u/
/e/	/o/
/ɛ/	/ɔ/
/a/	

5.1.1. Background

One way of investigating the sources of phonological change is to examine a language's synchronic phonetics, to test whether it has enhanced phonetic effects that could be linked or attributed to phonological alternations. The experiment described here considers that question by studying the acoustics of Romanian vowels, to understand the coarticulatory effects actually at play.

In this experiment I test for two sets of phonetic effects, each of which corresponds to a phonological process in Romanian; and I compare those to results from standard Italian. Since the phonological processes are directional, I also test the coarticulatory relationships that hold in the environment opposite the one triggering phonological alternation. The first effect involves the process that may have triggered metaphony in Romanian – namely, anticipatory vowel-to-vowel coarticulation in which phonetic characteristics of V2 trigger a change in V1. Metaphony is a phonological alternation in which a stressed low vowel – either front, central or back – alternates with the vowel one step higher than it in the vowel space, i.e. a mid vowel that is front, central or back. The quality of the stressed vowel is governed by the quality of the following unstressed vowel: the alternation [ẹa – e] requires the

unstressed vowel to be either front or non-front, while [o̯a – o] and [a – ʌ] depend on the presence of high front /i/ (see also §3.4.1). Examples appear in (5.1).

(5.1)   Romanian height-based vowel alternations

Alternation	Singular			Plural		
ea – e	[se̯arʌ]	seară	'evening'	[serʲ]	seri	'evenings'
oa – o	[no̯apte]	noapte	'night'	[noptsʲ]	nopți	'nights'
a – ʌ	[karte]	carte	'book'	[kʌrtsʲ]	cărți	'books'

Metaphony in Romanian is not completely surface-true; for example, although metaphony includes the process of /a/ raising to /ʌ/ before /i/, there are many instances in which /a/ is followed by a word-final /i/ without alternating (for a full description of metaphonic environments, see Chițoran 2002c). Metaphony has been largely morphologized and is found most often in singular-plural alternations and verb conjugations, which makes the presence of strong coarticulation particularly interesting because it occurs across a suffix boundary, and is also an instance of a weak phonological trigger for stressed-vowel alternations (Walker 2005). This refers to assimilatory patterns in which a "weak" element, such as an unstressed vowel, exerts an effect on a relatively "stronger" element, such as a stressed vowel. While the reverse pattern is common, weak triggers are not readily predicted by models of coarticulation; thus results pointing to weak trigger effects in Romanian are potentially interesting from a theoretical point of view. In the present study the targets of coarticulation are stressed vowels, and the triggers are either consonants or unstressed vowels (weak triggers), preceding or following the target.

The second phonological process of interest here is post-labial centralization (the Labial Effect), in which front vowels alternate with central vowels within a paradigm, without changing height, following a labial consonant but *not* preceding

another front vowel (Vasiliu 1966); examples appear in (5.2).[36] This process applies at all levels of vowel height but is no longer active in Romanian, and is limited to words that are either native or were borrowed long ago. This effect also surfaces in one morpheme, seen in the [ɨ − i] alternation of singular-plural pairs like [invʌtsʌmɨnt] − [invʌtsʌminte] 'education(s)'. The Labial Effect appears to interact with metaphony, as indicated by the [e – a] alternation in Figure 5.1 (below): where the expected outcome of Latin /e/ would be /ḙa/ in the Romanian singular, the Labial Effect instead triggers /a/; in the plural, however, metaphony blocks the /ḙa/ diphthong from surfacing.

(5.2)   The Labial Effect

Alternation	Singular			Plural		
a − e	[fatʌ]	*fată*	'girl'	[fete]	*fete*	'girls'
ʌ − e	[mʌr]	*măr*	'apple'	[mere]	*mere*	'apples'
ɨ − i	[vɨnʌtʌ]	*vânătă*	'eggplant'	[vinete]	*vinete*	'eggplants'

The present study tests for phonetic parallels to a process like the Labial Effect by comparing the effects of preceding and following consonants on a target vowel. A summary of these two sets of vowel alternations appears in Figure 5.1: metaphony works in the height dimension, while the Labial Effect affects the front-central dimension. This schematic emphasizes the asymmetrical involvement of certain vowels in these alternations: /u/, for example, participates in no alternations, while /i/, /ɨ/, /o/, /ḙa/ and /o̧a/ participate in one each; /ʌ/ and /a/ alternate with two other vowels, while /e/ alternates with three other members of the vowel system (/ʌ/, /a/ and /ḙa/).

---

[36] Cross-linguistically, phonetically-triggered changes like this are common in context where labials and front vowels are adjacent. In many cases, coarticulation between the two segments results in a consonantal change rather than a vocalic one, i.e. /pi/ → /ti/, in which the high F2 of /i/ causes reinterpretation of the labial consonant as one whose spectral characteristics have a higher-frequency locus.

	Front	Central	Back
High	/i/ ⟷ /ɨ/		/u/
Mid	/e/ ⟷ /ə/		/o/
Low	/ea/	/a/	/oa/

Figure 5.1.   **Vowel alternations in Romanian: Metaphony and the**
             Labial Effect

5.1.2. Romanian vowels: Initial evidence for vowel-to-vowel coarticulation

In studying the sources of variability in the phonetic realizations of Romanian vowels, I considered the possible effects of segments surrounding the target vowel, using the data collected in Chapter 4 (see Table 4.4 for word list). Specifically I was interested in possible parallels between synchronic acoustic effects and historical phonological patterns, and I focused my investigation on a subset of the tokens recorded for the basic acoustic study: target vowels /ʌ/ and /ɨ/, which were the most numerous. The phonological patterns of interest were metaphony and the Labial Effect. Each token of /ʌ/ or /ɨ/ was categorized along two dimensions: whether or not a labial consonant immediately preceded the target vowel, and whether or not an /i/ followed the target vowel.

5.1.3. Effect of /i/ on a preceding target vowel

In the phonology of Romanian we find many alternations that are governed by front vowels, particularly /i/, when it follows both vowels and consonants. For

186

example, consonants palatalize before /i/; and metaphony of both /ĕa/ and /ŏa/ to their mid-vowel counterparts /e/ and /o/ occurs before /i/. A possible source for these alternations is anticipatory coarticulation. While this historical process is now fully phonologized and interacts with Romanian morphology, we may find synchronic phonetic effects that parallel the historical changes, as argued for by e.g. Przezdziecki (2005). If this is the case and we find that the quality of V_2 does affect the formants of preceding V_1, then at least in some cases we also have evidence for weak triggers of coarticulation in Romanian.

In this subsection I examine the relationship between the formants of a target vowel (V_1) and a following /i/ (V_2) through statistical modeling. I predict that, if coarticulatory assimilation is taking place, the formants of V_1 should be globally affected by the quality of V_2, such that they are more similar to the expected values of V_2. In the case of $V_2 = $ /i/, which is tested here, I expect the first formant of V_1 to be lower, and the second formant to be higher, than before other vowels. If anticipatory coarticulatory effects are seen, we may use such findings to make predictions about articulatory planning models, and we might also expect consequences for speech perception; studies on the perceptual effects of anticipatory coarticulation have found evidence that listeners use coarticulatory information in tasks like word identification (Nguyen, Fagyal & Cole 2004).

To demonstrate the magnitude of coarticulatory effect caused by the presence of /i/ following the target vowel, Figure 5.2 compares the mean F1-F2 values for each of the vowels analyzed in the data set in Chapter 4, based on whether the target vowel was followed by a fully-realized [i]. In this figure, vowel tokens not followed by [i] are unfilled, and those followed by [i] are filled (in this data set, /e/, /a/ and /u/ did not appear in words with a final /i/). In general, targets followed by /i/ tend to move towards the front of the vowel space – particularly /ʌ/ and /ɨ/, for which the most data

187

is available, and which also seem to be the most variable in their realization of F1 and F2. The exception to this is /o/, which appears to dissimilate from the following /i/ in its frontness (it instead backs slightly), but its F1 lowers in that context. Even /i/ is more extreme – higher and slightly more fronted – when it precedes another [i]. Since female and male speakers tend to have different formant values, Figure 5.2 shows only female data.
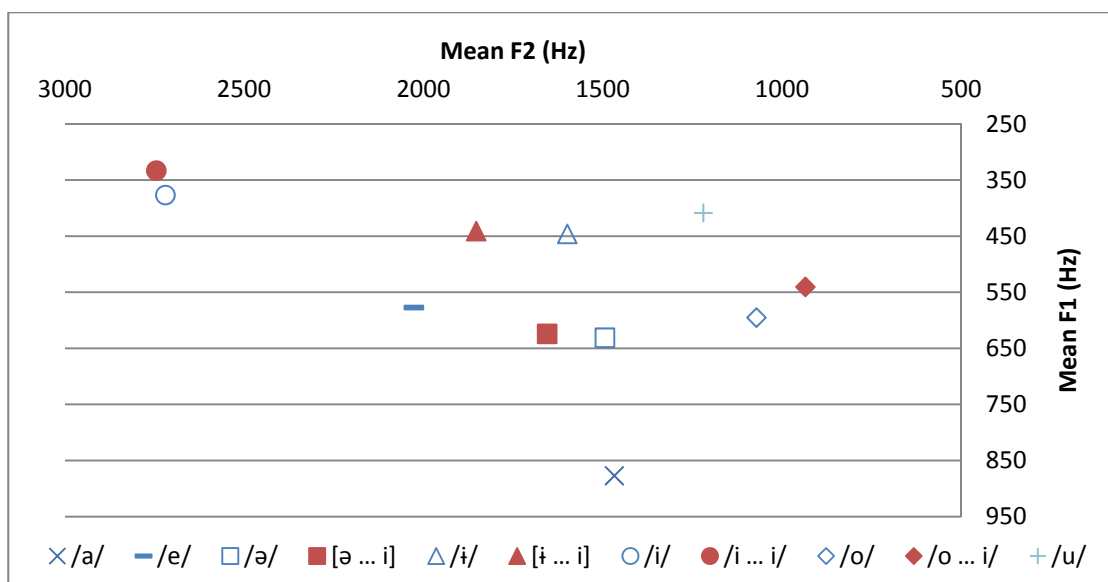
Figure 5.2. **Romanian vowels with and without a following /i/.**

Female speakers (non-normalized data, 14 speakers).

To further explore the effects of following vowels, in this case [i], I turn to the cases supported by the most data: the central vowels /ʌ/ and /ɨ/. Mean values and standard deviations for the first two formants, for female speakers' non-normalized data, is displayed in Table 5.2 for the two central vowels. The table shows that F2 is higher when followed by an [i], and lowest when followed by no front-vowel gesture; F2 values for central vowels with a following [ʲ] are intermediate.

Table 5.2.   **Mean values and standard deviations for the first two**

formants (Hz) of /ɨ/ and /ʌ/, pooled by speaker, separated by context

following the target vowel (14 female speakers; non-normalized data)

Vowel and context	Mean F1	SD F1	Mean F2	SD F2
/ʌ/				
following [i]	624	51	1655	116
following [ʲ]	637	62	1575	180
no front vowel	627	65	1448	175
/ɨ/				
following [i]	441	41	1853	191
following [ʲ]	435	33	1790	196
no front vowel	446	55	1588	194

The next two figures, Figure 5.3 and Figure 5.4, show individual data points
for /ʌ/ and /ɨ/ respectively, normalized by speaker,[37] graphed in F1-F2 acoustic space
and divided into three categories: tokens with a following [i], those with a following
palatal gesture [ʲ] (a high front vowel gesture, underlyingly /i/, i.e. a morphological
plural marker) and those without any following /i/-gesture. The patterns of data for
female speakers in these figures are also representative of male speakers. For both /ʌ/
and /ɨ/, the target vowel tends to be considerably further front when followed by /i/.

---

[37] Normalization procedures are detailed in Chapter 4.
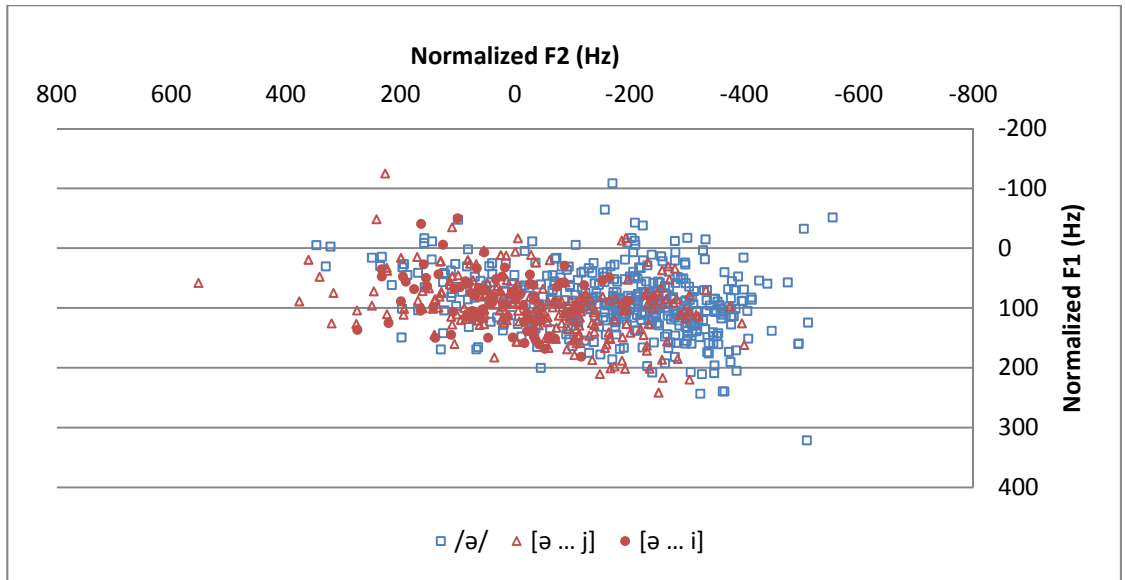
Figure 5.3.   **Romanian /ʌ/, with a following [i] or [ʲ], compared to tokens with no following front vowel. Female speakers (normalized data, 14 speakers).**
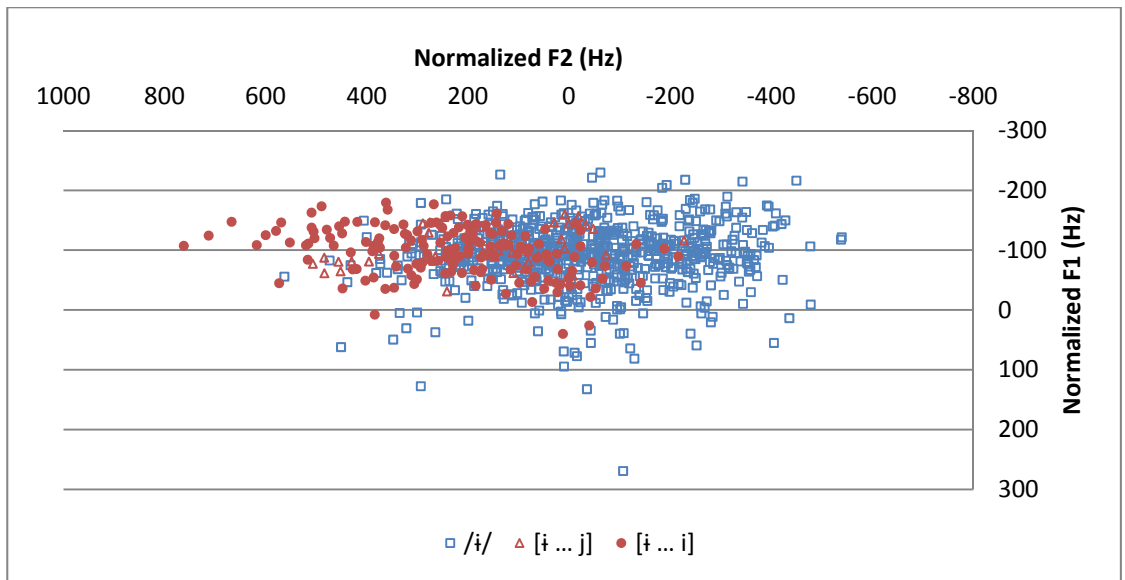
Figure 5.4.   **Romanian /ɨ/, with a following [i], [ʲ] or none, compared to tokens with no following front vowel. Female speakers (normalized data, 14 speakers).**

The specific pattern of coarticulation seen here – that vowels assimilate in an anticipatory fashion, particularly with high front vowels – is one that in fact mirrors phonological alternations in Romanian, such as the metaphonic processes undergone by the language's low vowels (Chiţoran 2002c). In the next subsection I show evidence for coarticulation with surrounding consonants, in a way that also parallels the phonologized alternation governed by labials.

5.1.4. Effect of a labial on a following target vowel

In describing the vowel space of Romanian, it is important to consider that the consonants flanking a target vowel may affect its formant values. This data set allows consideration of the effects of natural consonant classes based on place of articulation, specifically by comparing target vowels that are preceded by a labial consonant with those preceded by a consonant at a different place of articulation.

In Romanian a front vowel may, under certain circumstances, alternate with a central vowel /a/, /ʌ/ or /ɨ/ when preceded by a labial; for example, /ʌ/ alternates with /e/ in [vʌr] 'cousin (m.)' vs. [verʲ] 'cousins.' Although this effect applies to a small number of native words and is overridden by metaphony, it is possible that the historical roots of the alternation lie in a phonetic effect, which we might expect to parallel the synchronic acoustics. Such effects have been found in articulatory data from Turkish (Boyce 1990), which shows a pattern of lip rounding consistent with increased overlap across articulatory gestures. The data set presented here indeed shows that when a labial precedes a target vowel, the F2 of the target vowel is lowered by a significant amount, which does have the effect of backing the vowel – the reverse of the effect seen above with a following /i/ gesture. The effects are summarized below in Table 5.3 for female speakers' non-normalized data, which shows that F2 is

lowered by more than 200 Hz, for both /ʌ/ and /ɨ/, when a labial consonant precedes the vowel.

Table 5.3.   **Mean values and standard deviations for the first two formants (Hz) of /ɨ/ and /ʌ/, pooled by speaker, separated by context preceding the target vowel (14 female speakers; non-normalized data)**

Vowel and context	Mean F1	SD F1	Mean F2	SD F2
/ʌ/				
preceding labial	638	70	1368	118
no preceding labial	626	58	1597	168
/ɨ/				
preceding labial	439	51	1418	147
no preceding labial	446	53	1696	202

To visualize this effect, normalized F1-F2 data from female speakers are presented in the next two figures. Figure 5.5 shows tokens of /ʌ/ from two different contexts: the red triangles are vowel tokens preceded by a labial consonant, while the blue squares are tokens *not* preceded by a labial consonant. Figure 5.6 displays the equivalent data set from tokens of /ɨ/. In both cases, while there is overlap between the two subsets, the /BV/ tokens cluster farther back in the vowel space, and in some cases have an F2 several hundred Hertz lower than tokens not preceded by a labial. Besides demonstrating the extent to which stressed vowels in Romanian appear to coarticulate with surrounding consonants, the data in this subsection and in §5.1.3 above suggest potential sources for the considerable acoustic variability seen in /ʌ/ and /ɨ/. These two central vowels are subject to significant coarticulation with segments flanking them; thus the variation in their realization is not random, but is determined by the phonological environment.
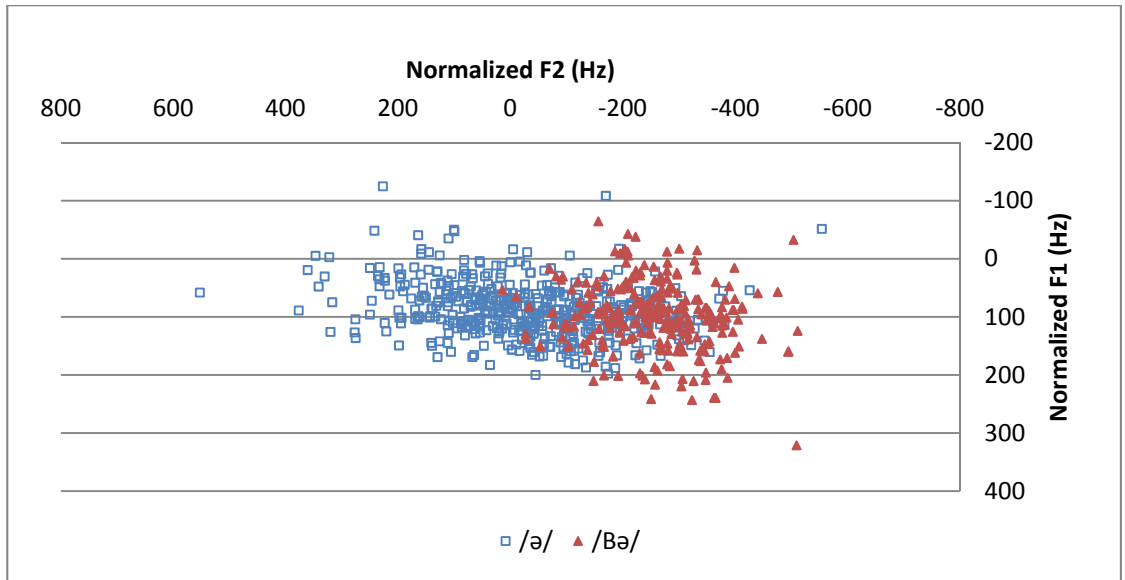
Figure 5.5.   **Romanian /ʌ/, preceded by a labial, compared with tokens not preceded by a labial. Female speakers (normalized data, 14 speakers).**
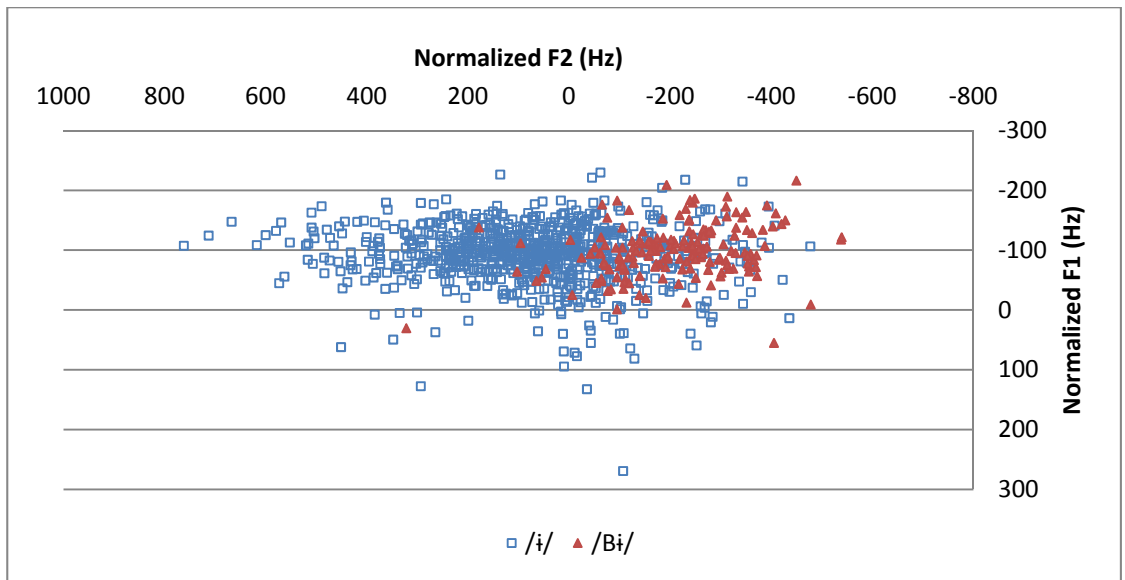
Figure 5.6.   **Romanian /ɨ/, preceded by a labial, compared with tokens not preceded by a labial. Female speakers (normalized data, 14 speakers).**

The pilot data examined so far in this chapter give evidence that vowels in Romanian coarticulate considerably with the vowels and consonants surrounding them. However, these pilot data examine only two target vowels in detail, and do not control for the effects of other surrounding segments, such as preceding vowels or following consonants. In order to quantify, compare and model the significance and magnitude of different types of coarticulation in Romanian, the next sections present a controlled acoustic experiment comparing standard Romanian with standard Italian.

5.2.   Comparing coarticulation in Romanian and Italian

The pilot data in §5.1 demonstrate that vowels take on the acoustic characteristics of a following /i/, and also of a preceding labial gesture: in the first case, vowels tended to have lower F1 and higher F2 values, similar to those of /i/; and in the second, F2 is lowered. These are coarticulatory phonetic effects that could be exaggerated to create a vowel alternation: for example, before an /i/, the lowering of F1 could cause an /a/ to be realized similarly to an /ʌ/, as in the metaphonic alternations described in §5.1. The study outlined below, in which segmental content is balanced and entirely controlled, allows a precise cross-linguistic comparison of these different coarticulatory effects.

Here, Romanian is compared to Italian, a Romance language whose standard varieties exhibit no vowel quality alternations governed by segmental context. Among studies of coarticulation, those within language families include investigations of the effects of intervening consonants on vowel-to-vowel coarticulation in Catalan and Spanish (Recasens 1987) and comparisons of vowel-to-vowel effects in the Bantu languages (Manuel & Krakow 1984; Manuel 1990; Manuel 1999). Experimental work has demonstrated the presence of anticipatory coarticulation in French (Fagyal, Nguyen & Boula De Mareüil 2003; Nguyen & Fagyal 2008), which shows

194

phonological metaphony (assimilation of unstressed mid-vowels to stressed final vowels) in some dialects. To my knowledge, there are no comparisons of related languages for the purposes of isolating the role of phonological processes, as executed here.

An area on which more studies have focused is the comparison of anticipatory vs. carry-over effects. For English, studies of vowel-to-vowel coarticulation generally indicate larger carry-over effects in unstressed vowels (Bell-Berti & Harris 1976; Fowler 1981; Parush, Ostry & Munhall 1983), although for stressed vowels, anticipatory and carry-over effects are smaller in magnitude than for unstressed vowels and are roughly symmetrical (Fowler 1981). In a comparison of Swedish, English and Russian, Öhman (1966) found greater anticipatory coarticulation in the first two languages than in Russian, noting that vowel context and manner of consonant articulation are also relevant for the rate of coarticulation.

One cross-linguistic study (Manuel & Krakow 1984) reported large differences across languages; in the Bantu language Shona, anticipatory effects were greater than corresponding carry-over effects in English. Beddor et al. (2002), by contrast, found comparable but significant amounts of anticipatory coarticulation for these two languages, but greater carry-over coarticulation of vowels in English. The use of this language pair may be the best available comparison for the present study. While English does not show phonological alternations as a function of flanking vowel quality, Shona does have a process of vowel harmony, in which mid vowels contrast only in root-initial syllables, but in subsequent syllables may be neutralized depending on the quality of the root-initial vowel (Beckman 1997). However, the results of Beddor et al.'s (2002) study do not indicate direct parallels between the phonology and the phonetics in Shona, which would predict large amounts of carry-over coarticulation. Another study, by Magen (1984), found a preference for anticipatory

195

V-to-V coarticulation in Japanese. Overall, as reviewed by Manuel (1999), studies have found varied results with regard to the relative strengths of anticipatory vs. carryover coarticulation, which also vary across speakers of a single language.

The study presented here shows asymmetrical effects of anticipatory vs. carryover coarticulation, which differ additionally across languages and target vowels. The experiment is an acoustic study of nonce words in Romanian and Italian, in which target vowels' formants are measured, compared, and tested for the effects of coarticulation with preceding and following consonants and vowels. This analysis allows consideration of questions relevant to modeling the relationship between phonetics and phonology. First, we are able to test the extent to which synchronic patterns parallel historically-developed phonological patterns. Secondly, we can test the model of Adaptive Dispersion Theory (Liljencrants & Lindblom 1972; Lindblom 1986), specifically the idea that a vowel's variability is affected by the size of the vowel system in which it is found. This includes Manuel's (1990) related claim that systems tend to avoid vowel-to-vowel coarticulation when it would increase confusion between phones, in a way that is related to the number of vowels in a particular system.

If the coarticulatory properties exhibited by Romanian are tied to its phonology, as suggested by the pilot results, I predict different results in a language that lacks alternations like metaphony and centralization. As a null hypothesis, I propose that in Italian, we expect to find that vowel-to-vowel and consonant-vowel articulation are symmetrical with respect to preceding and following segments; they should have equal effects on the target vowel's formant values. However, the results may permit a variety of claims regarding the differences between Italian and Romanian. If the effects of preceding and following vowels are equal in Italian but asymmetrical in Romanian, then we have evidence for a link between phonological

196

alternation and increased phonetic effects paralleling that alternation. These results can shed light on whether models should predict different levels of coarticulation across languages with different phonologized segmental interactions, as in Romanian vs. Italian. It may be the case that Italian, which lacks active interactions of this type, represents a 'default' level of coarticulation, but in Romanian certain effects are relatively greater. In addition to statistical modeling of the data, it is also crucial to consider the *magnitude of effect* of coarticulation in each context. This is a measure, separate from analyses of statistical significance, of the size of acoustic differences from one coarticulatory context to the next; I calculate it across languages, target vowels, flanking vowels, or any available set of contrasting contexts.

I offer several testable predictions regarding the relative strengths of different coarticulatory effects, and these predictions form the basis of the experiment described here. First, in Romanian, I predict that target vowels' formants are affected more by following vowels than preceding vowels. Specifically: F1 and F2 should be more /i/-like – lower and higher, respectively – when followed by that vowel. Second, if phonetics parallels phonology, I predict that target vowels' formants are affected more by preceding consonants than by following consonants: post-labial backing works from left to right, but right-to-left vowel alternations *triggered by consonants* do not synchronically occur. Specifically: F2 should be lower when preceded by a labial.

To foreshadow the results, this experiment finds some evidence for greater vowel dispersion in Romanian with respect to Italian, which means that its overall vowel system is relatively larger in the phonetic space. It also finds that when phonological environment is taken into account, variability in Italian tends to be greater than in Romanian, which requires a more nuanced analysis than that of Manuel (1990), who predicts a link between inventory size and rates of coarticulation but does not take phonological processes into account. Additionally, the magnitude of

coarticulatory effects is consistently greater in Romanian than in Italian, which parallels the phonologically-based predictions; but in both languages, magnitudes of coarticulation vary widely across target vowels and coarticulation contexts.

5.2.1. Vowel inventory size in Romanian and Italian

Where Adaptive Dispersion Theory and Manuel's (1990) articulatory output constraints are concerned, it is necessary to take vowel inventory size into account. While the inventories provided in Table 5.1 show Romanian as a nine-vowel system and Italian as a seven-vowel system, methodological constraints and the make-up of these inventories complicate a comparison on these terms. For the purposes of this experiment, I treat Romanian as a system of seven monophthongs (five peripheral vowels and two central vowels), and Italian as a seven-vowel system, but in which only five vowels may be distinguished here.

This complexity in Italian is due to the status of [e] vs. [ɛ] and [o] vs. [ɔ]. In discussions of Italian phonology each of these four vowels is considered phonemic; [e] and [o], the two high-mid vowels, are commonly known as 'open' vowels, while [ɛ] and [ɔ], the low-mids, are 'closed' (see e.g. Kenstowicz 2010 for a discussion). These vowels contrast only in stressed position; in unstressed position, they reduce to low-mid vowels. However, a small study of this contrast (Ladd 2006) indicates considerable inter-speaker disagreement on lexical vowel quality where the high-mid vs. low-mid contrast is concerned, particularly for front vowels; thus the synchronic status of the contrast is unclear. Additionally there is no way to distinguish between the 'open' and 'closed' vowels in Italian orthography, making it difficult to elicit this contrast without explicit instruction and additional explanation to speakers. Despite methodological efforts to record nonce words with consistent differentiation between mid and low-mid vowels, I was unable to obtain this contrast in my data (see §5.4).

However, the phonological system of Italian does comprise seven vowels, so for the purposes of ADT I assume an inventory of that size.

Romanian, on the other hand, has an inventory of seven monophthongs plus the two monomoraic diphthongs /e̯a/ and /o̯a/, all of which can be differentiated orthographically and analyzed separately. However, the diphthongs have two acoustic targets (see Chapter 4) which overlap with those of the monophthongs /e/, /o/, and /a/, which are already included in the analysis; thus the diphthongs are not expected to expand the vowel space phonetically. Furthermore, their phonetic structure differs substantially from that of the monophthongs, which renders a direct comparison of rates of coarticulation difficult across the two sets of sounds. For these reasons, Romanian is treated as a seven-vowel system.

Under this assumption, both ADT and articulatory output constraints (Manuel 1990) predict similarity between Italian and Romanian, of overall dispersion in the first case and of rates of coarticulation and vowel overlap in the second. Applying these models here, any differences we do find across Romanian and Italian can be more clearly linked to the influences of phonological differences (i.e. the vowel alternations of Romanian), which are the remaining dimension along which the languages differ.

Alternatively, one could assume that Romanian and Italian do not in fact have equivalently-sized vowel systems; maximally, Romanian has nine vowels, while Italian minimally has five. In the case of such a discrepancy in inventory size, Manuel (1990) in particular would predict greater rates of coarticulation in Italian than Romanian, due to the former's relatively uncrowded vowel space. Under that analysis, a finding of the reverse pattern – significant coarticulation in Romanian in the contexts of phonological alternation – would even more sharply call into question the predictions of articulatory output constraints.

To summarize: This experiment treats Romanian and Italian as two seven-vowel systems, although in Italian the methodology constraints us to only five distinguishable phonetic categories.

5.3.   Methods

This acoustic experiment recorded nonce word stimuli embedded in a frame sentence, using the methodology described generally in §4.2. Nine Romanian speakers and eight Italian speakers participated. Four of the Romanian speakers were recorded in the United States, in the Cornell University Phonetics Laboratory; three speakers were recorded in the phonetics laboratory at the Faculty of Letters of Babeş-Bolyai University, Cluj-Napoca, Romania; and two speakers were recorded in quiet environments elsewhere in Cluj-Napoca. Eight women and one man were recorded. Of the Italian speakers, five were female and three were male; one was recorded in a quiet environment in Sasso Marconi, Italy; the others were recorded at the Cornell Phonetics Laboratory. All files were digitally recorded, either onto a digital recorder or directly onto a laptop computer, with a sampling rate of 44 kHz.

5.4.   Materials

Speakers read aloud a series of phonotactically licit nonce words, each containing one target vowel for analysis. In each nonce word vowels and consonants were systematically varied both preceding and following the target vowel, which was the second, and stressed, syllable in a three-syllable word; a summary of this format appears in (5.3). In both languages, all words began with /k/ (C_1) and were followed by /i/ or /a/ (V_1), which was the preceding vowel environment. In Romanian, the second syllable (containing the target vowel) began with either /p/ or /ts/; in Italian, it began with /p/ or /tʃ/ (C_2). The target vowel (V_2) followed, and the third syllable began

in Romanian with /p/ or /ts/, and with /p/ or /tʃ/ in Italian (C_3). The final vowel in the word was either /i/ or /a/ (V_3). The logical combinations of these segments appear in (5.4) and (5.5) below.

(5.3)   Stimulus format: $/k\ V_1\ C_2\ V_2\ C_3\ V_3/$

(5.4)   Stimuli in Romanian: $/k\ \begin{Bmatrix}i\\a\end{Bmatrix}\begin{Bmatrix}p\\ts\end{Bmatrix}V_2\begin{Bmatrix}p\\ts\end{Bmatrix}\begin{Bmatrix}i\\a\end{Bmatrix}/$

(5.5)   Stimuli in Italian: $/k\ \begin{Bmatrix}i\\a\end{Bmatrix}\begin{Bmatrix}p\\t\!\int\end{Bmatrix}V_2\begin{Bmatrix}p\\t\!\int\end{Bmatrix}\begin{Bmatrix}i\\a\end{Bmatrix}/$

Each target vowel was placed in all the logical combinations of the aforementioned conditions, producing 16 nonce words per target vowel (V_2); vowels for each language are listed in Table 5.4. For Romanian this produced a total of 144 words (7 monophthongs plus 2 diphthongs /e̯a/ and /o̯a/). For Italian there were a total of 80 words, plus 32 more in which the vowels /o/ and /e/ were placed before geminate /p:/ and /tʃ:/ in an attempt to create a contrast within the data set between /o/ and /ɔ/, and /e/ and /ɛ/.[38] Examples appear in Table 5.5, showing all the combinations of preceding and following segments that were used, in the full paradigm of stimuli for the target vowel /i/ in each language.

It has been found in base-of-articulation studies that syllable structure, not just the qualities of surrounding segments, can affect the basic acoustic properties of vowels across languages (Bradlow 1993). The use in this study of nearly-identical segmental and prosodic frames helps to allay any concern of methodologically-induced differences in the vowel space.

---

[38] For the first three speakers recorded, there was no clear difference between the vowels produced before singleton and geminate consonants. To make statistical modeling simpler, I therefore excluded from my analysis the vowels produced before geminates. My results may include realizations of both types of vowels, in continuous front- and back-mid vowel clusters, with no clear boundary based on height; thus two phonological categories may be subsumed in my data.

Table 5.4.   **Target vowels, by language**

Romanian		Italian
Monophthongs	Diphthongs	
/a/	(/ẹa/)	/a/
/e/	(/ọa/)	/e/
/ʌ/		(/ɛ/)
/o/		/o/
/i/		(/ɔ/)
/ɨ/		/i/
/u/		/u/

Table 5.5.   **Paradigm of stimuli used in acoustic experiment, target**

vowel /i/ (target V₂ shown in bold)

Romanian		Italian	
Orthography	Transcription	Orthography	Transcription
chipipii	ki'**pi**pi	chipipi	ki'**pi**pi
chipipa	ki'**pi**pa	chipipa	ki'**pi**pa
chipiţii	ki'**pi**tsi	chipici	ki'**pi**tʃi
chipiţa	ki'**pi**tsa	chipicia	ki'**pi**tʃa
chiţipii	ki'ts**i**pi	chicipi	ki'tʃ**i**pi
chiţipa	ki'ts**i**pa	chicipa	ki'tʃ**i**pa
chiţiţii	ki'ts**i**tsi	chicici	ki'tʃ**i**tʃi
chiţiţa	ki'ts**i**tsa	chicicia	ki'tʃ**i**tʃa
capipii	ka'**pi**pi	capipi	ka'**pi**pi
capipa	ka'**pi**pa	capipa	ka'**pi**pa
capiţii	ka'**pi**tsi	capici	ka'**pi**tʃi
capiţa	ka'**pi**tsa	capicia	ka'**pi**tʃa
caţipii	ka'ts**i**pi	cacipi	ka'tʃ**i**pi
caţipa	ka'ts**i**pa	cacipa	ka'tʃ**i**pa
caţiţii	ka'ts**i**tsi	cacici	ka'tʃ**i**tʃi
caţiţa	ka'ts**i**tsa	cacicia	ka'tʃ**i**tʃa

Speakers of Romanian read each stimulus in the frame sentence *Spune X da trei ori* 'Say X three times,' while the Italian stimuli appeared in *Dice X da tre ore* [ˈditʃe *X* da tre ˈore] 'He's been saying X for three hours.' While these two frame sentences have different meanings, they have similar phonological and prosodic content.

202

The sentences were recorded in a randomized order; each was read three times, at a normal ("neither fast nor slow") rate of speech. For Romanian, 144 unique words were recorded three times each for a total of 432 tokens per speaker; in Italian, 80 unique words produced 240 tokens per speaker. For nearly every speaker, the presence of speech errors undetected during recording resulted in the exclusion of a few vowel tokens. Data were extracted from a total of 3,876 Romanian tokens and 1,906 Italian tokens.

Each target vowel was annotated using text grids in Praat (Boersma & Weenink 2010), and formant values for F1, F2 and F3 were automatically extracted at three points during each vowel: at 25%, 50% and 75% of the vowel's duration, which was also measured. The data were then coded to indicate the preceding and following vowels and consonants for each vowel, and the formant measures were hand-corrected. The onset and offset of each target vowel was marked using the techniques detailed in Chapter 4; example spectrograms appear below for two nearly-identical nonce words; Romanian /katsitsa/ (Figure 5.7) and Italian /katʃitʃa/ (Figure 5.8).
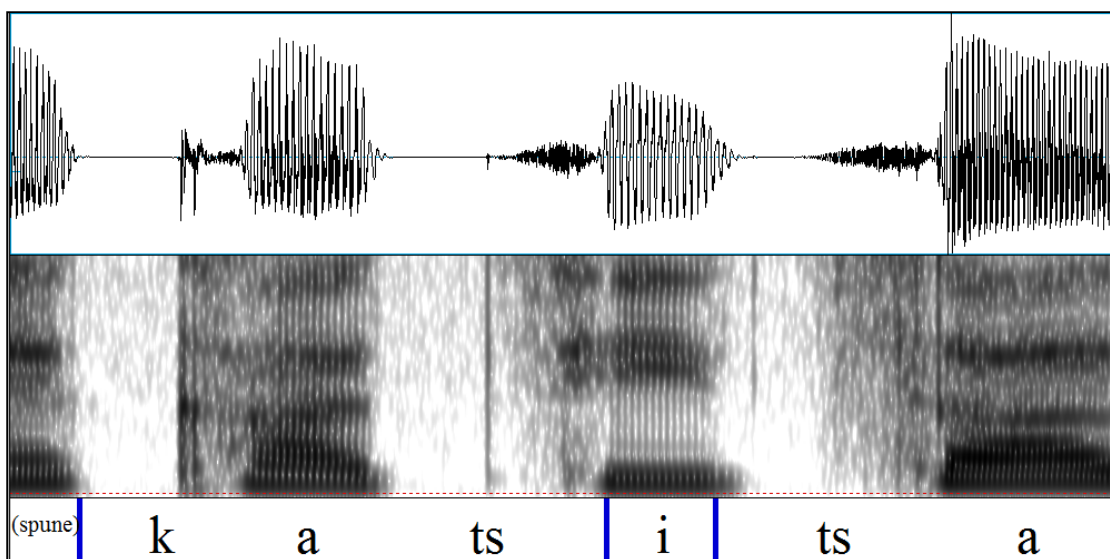
Figure 5.7.   **Spectrogram: Romanian [kaˈtsitsa]**
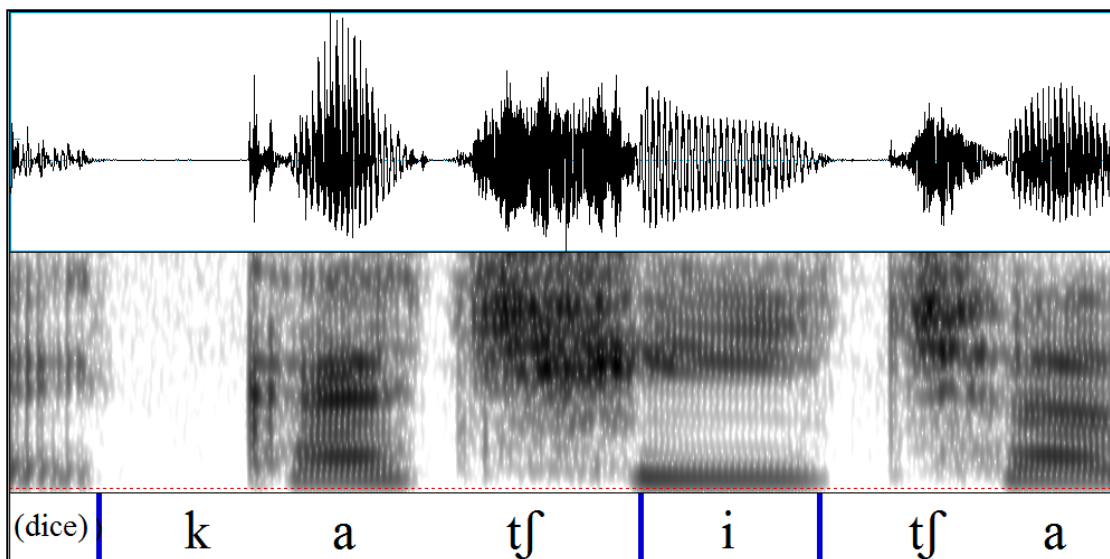
Figure 5.8.　**Spectrogram: Italian [kaˈtʃitʃa]**

The corrected data were normalized using the following method, adapted from Chen (2008). For each speaker, the mean (μ) F1 and F2 values were calculated over all vowel types, then subtracted from the value of each non-normalized data point (at the midpoint of the vowel only), resulting in values centered around a mean of (0, 0). That normalized difference was then divided by the standard deviation (σ) of the overall mean value for the relevant formant for a particular speaker, providing a z-score (z) for each token. Once the data were normalized, outliers were excluded: I calculated the standard deviations of F1 and F2 for each speaker, for each vowel, and compared the normalized values of data points to $2(\sigma_{normalized})$. [39] Normalized data points that lay more than 2σ from their mean of (0), on the basis of either their F1 or F2 value, were excluded. The data were then re-normalized, using the raw F1 and F2 values for the remaining data points. A total of 283 vowel tokens (7.3%) were excluded from the Romanian data, and 150 (7.9%) were excluded from the Italian data, leaving a total of

---

[39] This is computationally equivalent to calculating the z-score for each data point, and excluding all z-scores greater than 2.0.

3,593 tokens for the statistical analysis of Romanian, and 1,756 for the statistical analysis of Italian.

The results that follow below use either non-normalized data (in which case no data points are excluded) or normalized data, depending on the nature and goals of each particular analysis.

5.5. Results

5.5.1. Review of predictions

The null hypothesis for this experiment is that coarticulatory effects from preceding and following consonants are approximately equivalent, and that those from preceding and following vowels are also symmetrical. Large differences between Italian and Romanian may be due to the languages' differing phonological patterns. Specifically, in accordance with pilot data, I predict:

- In Romanian, the effect of a following vowel on a target vowel's formants should be greater than that of the preceding vowel (anticipatory > carryover).
- The effect of a preceding consonant on a target vowel's formants should be greater than that of the following consonant, in Romanian (anticipatory < carryover).

Compared to Italian, I expect to find larger magnitudes of effects in Romanian in both these cases.

I first report the effects of surrounding vowels on F1 and F2, which are summarized with example figures showing these effects for one Romanian and one Italian speaker. I compare results in the two languages first at the level of mean

formant values, by vowel context, for each language. I then examine in more detail the magnitudes of the differences between the means when the preceding or following vowel is systematically varied. This analysis is later repeated to examine the effects of surrounding consonants on F1 and F2 in each language.

5.5.2. Effect of surrounding vowels

This portion of the results focuses on trends in F1 and F2, in Italian and Romanian, as a function of the initial (V_1) or final (V_3) vowel in each stimulus, where V_2 is the target vowel whose formants are measured. To summarize the effects that are later modeled statistically, a set of figures below show the acoustic vowel space of one female Italian speaker (ItF1) and one female Romanian speaker (RoF1). In these figures the data points are differentiated not by vowel type (which is indicated with labeled ovals), but by V_1 in the case of Figure 5.9 and Figure 5.10, and V_3 in the case of Figure 5.11 and Figure 5.12. Tokens flanked by /a/ are indicated with filled diamonds, while when /i/ is the relevant vowel, tokens are signaled with unfilled squares.

5.5.2.1. Results: Effects of preceding vowels

In the Italian data in Figure 5.9, labeled in terms of the vowels *preceding* (V_1) each target vowel, there is complete overlap between tokens with different preceding vowels. There is no clear separation of the vowel space based on V_1, but there may be some effect. For certain vowels, especially /i/, /e/ and /u/, which do appear slightly higher and further to the front when V_1 = /i/ than when V_1 = /a/. This is tested statistically below.

206
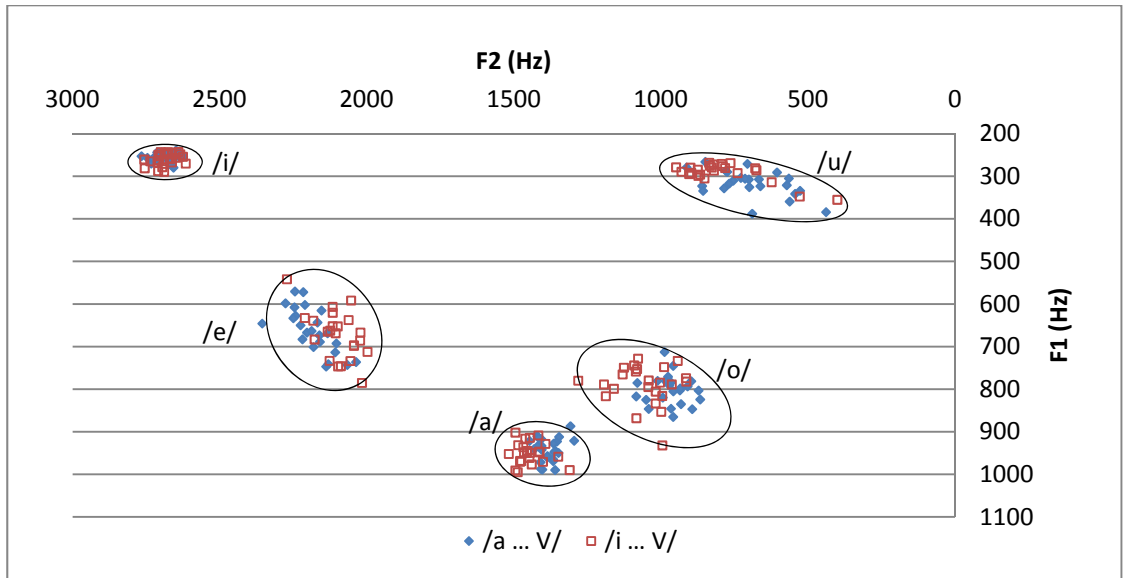
Figure 5.9.   **Acoustic F1-F2 space for V_2, Italian speaker ItF1; data points split by preceding vowel (non-normalized data)**

Figure 5.10 shows the data from Romanian speaker RoF1 and as in the Italian data, there are no obvious effects of preceding vowels. An effect of preceding vowels would be indicated by vowel fronting after /i/, but this is not apparent. Instead, targets preceded by /a/ and /i/ appear to overlap completely, with the possible exception of target vowel /i/, in which some tokens with V_1 = /i/ appear to be further front and higher than those preceded by /a/.
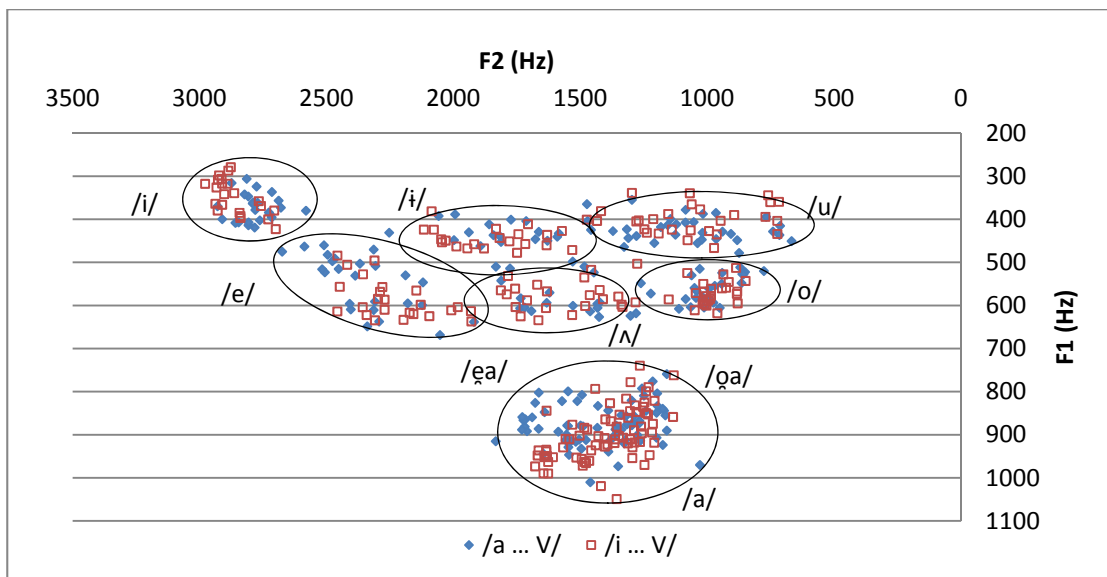
Figure 5.10.   **Acoustic F1-F2 space for V₂, Romanian speaker RoF1; data points split by preceding vowel (non-normalized data)**

5.5.2.2. Results: Effects of following vowels

In this subsection, I consider the differences between tokens based on their final vowel (V_3); thus these data are either '/a/-final' or '/i/-final.' In the Italian data in Figure 5.11 the measurements are tightly clustered within each vowel type; /i/ is a particularly striking example of this. While /i/ is the most tightly-clustered vowel, /a/ has only marginally more variability, while /e/, /o/ and /u/ are more variable. In this figure, there is no evidence for significant coarticulation based on the following-vowel environment: the filled and unfilled data points are overlapping for all five vowels in the system.
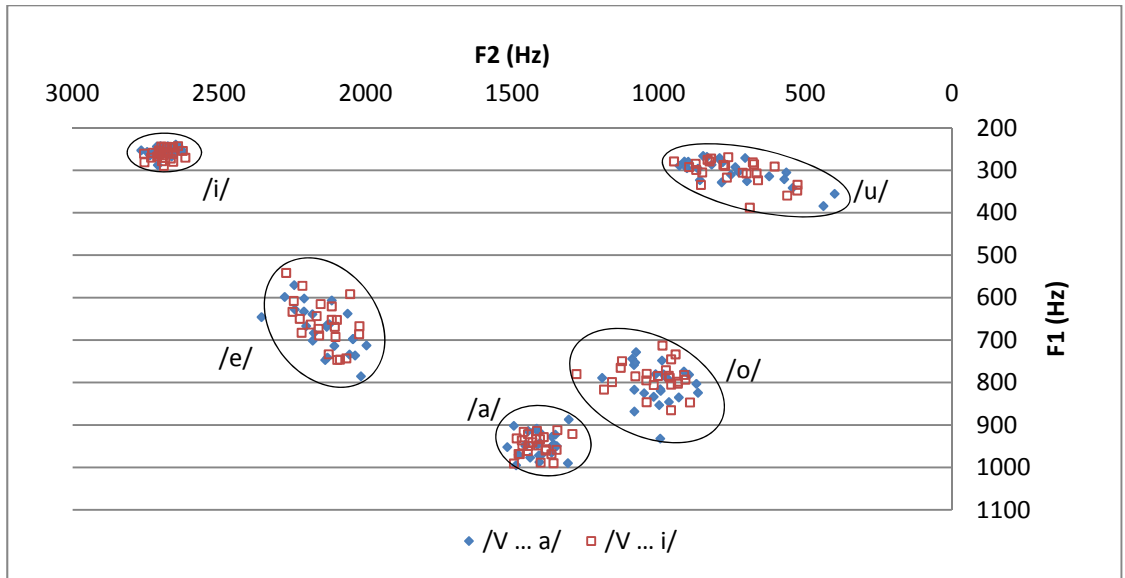
Figure 5.11. **Acoustic F1-F2 space for V_2, Italian speaker ItF1; data points split by following vowel (non-normalized data)**

In the Romanian data in Figure 5.12 the picture is strikingly different. First, there is no clear separation between certain vowel types; the five vowels /e/, /ʌ/, /o/, /ɨ/, /u/ are all adjacent or overlapping in the F1-F2 plane, and do not appear to cluster around a clear midpoint within each type. One question to which I return later is whether this high variability is random or systematically triggered by coarticulation. There are clear differences in F1 and F2 between the two following-vowel environments, but the effects vary from one target vowel to another: among tokens of /e/, many /i/-final tokens are farther front in the acoustic vowel space than the /a/-final ones. A similar effect is seen for /ɨ/ and /ʌ/; and for target vowel /i/, the /i/-final tokens tend to be farther front, but also slightly lower, than /a/-final tokens. At the back of the vowel space, for /o/ and /u/, there are no clear effects of following vowel; and among the low vowels /a/, /e̯a/ and /o̯a/ there is so much acoustic overlap that no

209

generalizations can be drawn without statistical modeling.[40] In sum, it appears that Romanian vowels exhibit high F1-F2 variability, and that there are clear effects on F1-F2 depending on V$_3$, but the presence or magnitude of those effects in turn depends on the target vowel.
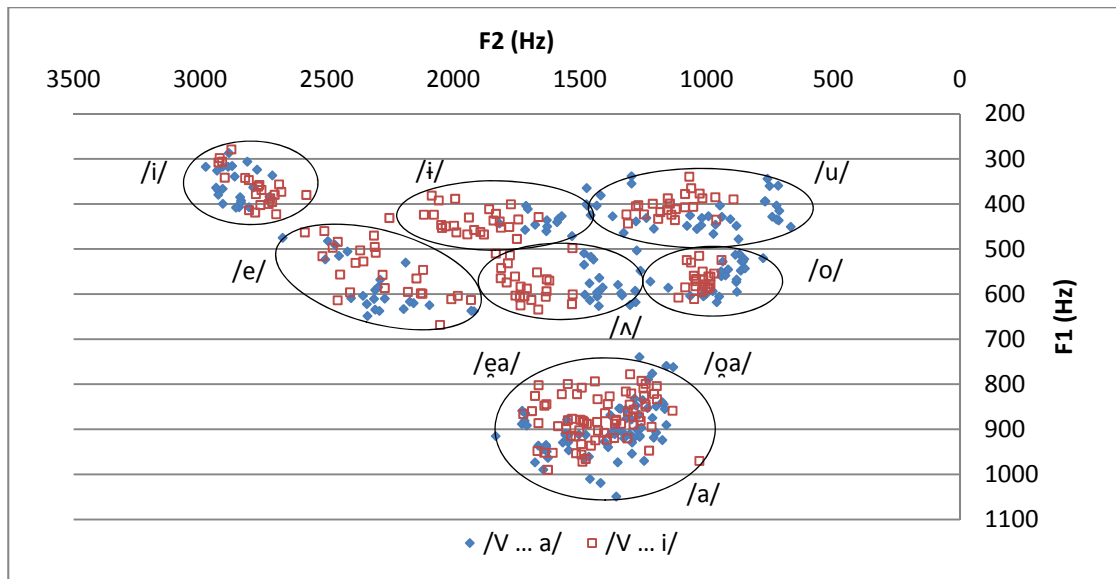
Figure 5.12. **Acoustic F1-F2 space for V$_2$, Romanian speaker RoF1; data points split by following vowel (non-normalized data)**

---

[40] The diphthongs are best modeled as vowels with two separate targets – an initial mid-vowel target, followed by an /a/ target, as seen in Figure 4.18. Since F1-F2 measurements fell at the vowel midpoint, the /a/ portion of the diphthongs was sampled rather than the /e/ or /o/ portion. These data points should thus be understood as indicating formant values from samples within an /a/ target, or from late in the mid-to-low transition between targets. For this reason, the effects of coarticulation are not visible on the two steady states separately; however, examination of formant trajectories of the diphthongs indicates that in these stimuli, the amount of coarticulation with preceding and following segments is comparable to that of other Romanian vowels.

5.5.3. Quantifying and comparing differences: Effects of surrounding vowels

Next I quantify the differences in F1 and F2 for each vowel type depending on V_1 or V_3, which allows comparison of the rates of carryover and anticipatory vowel-to-vowel coarticulation. The following tables show mean values for F1 and F2, across speakers, by vowel, for Romanian and Italian. In these tables, only data from female speakers is shown; male speakers' data is shown in Appendices D and E. Within each language and vowel type, the mean measurements are divided into two categories: those in which the measured target vowel was preceded or followed by [a], and those in which it was preceded or followed by [i]; standard deviations for each environment are also shown. The differences across environments – for example, the differences between the means of F1, for Romanian target vowel /o/, in each V_3 environment – are extracted for analysis below.

Table 5.6 displays mean formant values for V_2 based on preceding vowel quality (V_1), showing the extent of carryover coarticulation across Italian and Romanian. This is calculated across all female speakers' non-normalized data, when it is split into targets with $V_1 = $ /a/, and $V_1 = $ /i/. For the five vowels present in both languages (/a/ /e/ /i/ /o/ /u/), this table shows that F1 and F2 values are comparable, with the exception of /o/: in Italian, this vowel has a higher F1 (approx. 715 Hz) than in Romanian (approx. 575 Hz). The F2 of Italian /o/ is also higher, indicating a more fronted realization than in Romanian. Other differences in the vowel space (i.e. placement of /e/, /a/, /i/, /u/) are smaller across the two languages. Examining the Standard Deviations columns, it appears that Romanian may have consistently higher SDs than Italian, indicating greater variability; this is examined quantitatively below.

211

Table 5.6.   **Mean formant values, by preceding vowel (V_1): Female speakers**

	Italian – F1						Italian – F2					
	V_1 = /a/			V_1 = /i/			V_1 = /a/			V_1 = /i/		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	890	74	118	891	65	121	1470	152	118	1485	157	121
e	515	104	120	512	91	120	2304	207	120	2348	178	120
i	303	47	120	299	46	119	2644	88	120	2663	70	119
o	709	77	121	724	81	118	1136	164	121	1142	158	118
u	346	54	119	344	50	120	859	206	119	920	238	120
	Romanian – F1						Romanian – F2					
	V_1 = /a/			V_1 = /i/			V_1 = /a/			V_1 = /i/		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	871	100	192	875	106	191	1403	159	192	1417	148	191
e	554	55	191	588	50	191	2198	221	191	2147	201	191
ʌ	593	60	191	631	70	191	1468	201	191	1481	190	191
ea	866	90	188	880	95	193	1711	133	188	1694	137	193
i	336	42	192	325	40	189	2728	110	192	2736	114	189
ɨ	407	38	193	404	37	193	1578	272	193	1628	260	193
o	571	60	192	587	57	190	998	119	192	1018	116	190
oa	818	114	193	828	112	192	1248	110	193	1261	106	192
u	403	42	192	399	38	191	949	193	192	986	211	191

Table 5.7 also shows all the female speakers' non-normalized data, split based on the following vowel (V_3), into V_2 targets with V_3 = /a/, vs. V_3 = /i/. This comparison of anticipatory coarticulation effects shows that in both languages, the differences in F1 across the two contexts are small; the biggest difference appears to be in Romanian /e/, with a mean F1 of 598 Hz before /a/, and 543 Hz before /i/, indicating vowel raising in that anticipatory context. Turning to F2, there are differences of only a few Hertz across the contextual means in Italian, but in Romanian the differences are larger, especially for /e/ (181 Hz), /ʌ/ (39 Hz) and /ɨ/ (89 Hz). This is tentative support of my hypothesis regarding the relative effects of preceding and following vowels, namely that following vowels are more likely to have effects in Romanian. Standard deviations across the two languages appear variable across vowel types, but comparable across the two languages, for vowels that occur in both Italian and Romanian.

Table 5.7.   **Mean formant values, by following vowel (V_3): Female speakers**

	Italian – F1						Italian – F2					
	V_3 = /a/			V_3 = /i/			V_3 = /a/			V_3 = /i/		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	883	68	119	897	71	120	1469	153	119	1486	157	120
e	522	98	120	506	96	120	2309	201	120	2343	186	120
i	302	49	122	300	44	117	2652	87	122	2655	72	117
o	720	81	118	714	77	121	1134	157	118	1144	164	121
u	345	53	121	344	52	118	895	243	121	885	205	118
	Romanian – F1						Romanian – F2					
	V_3 = /a/			V_3 = /i/			V_3 = /a/			V_3 = /i/		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	869	99	191	878	107	192	1396	157	191	1424	149	192
e	598	50	192	543	45	190	2083	195	192	2264	190	190
ʌ	622	65	191	603	69	191	1455	189	191	1494	200	191
ea	874	92	191	872	93	190	1688	134	191	1717	135	190
i	331	41	192	331	42	189	2729	110	192	2735	113	189
ɨ	408	36	191	403	39	195	1558	251	191	1647	275	195
o	582	58	190	577	60	192	1012	117	190	1003	119	192
oa	823	113	192	824	113	193	1243	102	192	1266	112	193
u	403	40	191	399	40	192	962	202	191	974	204	192

The results in Table 5.6 and Table 5.7 suggest important differences in coarticulation and vowel variability – not only across Italian and Romanian, but even within a single language, as seen in the large differences in standard deviation across vowel types, or in the varying degrees to which different vowel types are affected by a change in coarticulatory context.

5.5.3.1. Preceding and following vowel effects in Italian

Having examined mean formant values across the V_1 and V_3 coarticulatory contexts, I now turn to a quantitative comparison of the differences in V_2 formant values, as triggered by a change in the quality of V_1 or V_3. This is accomplished by taking the difference in means across each coarticulatory context, by calculating the difference between the mean formant value (F1 or F2) in the /a/ coarticulatory context (i.e. V_1 = /a/ for carryover coarticulation, or V_3 = /a/ for anticipatory coarticulation)

and the mean formant value in the /i/ coarticulatory context. Formulas are shown in (5.6) and (5.7).

(5.6)   Carryover: $[\text{Mean}(V_2) \text{ when } (V_1 = a)] - [\text{Mean}(V_2) \text{ when } (V_1 = i)]$

(5.7)   Anticipatory: $[\text{Mean}(V_2) \text{ when } (V_3 = a)] - [\text{Mean}(V_2) \text{ when } (V_3 = i)]$

The result of this subtraction is a *difference in means*, specific for each comparison of V_1 or V_3 contexts, within each formant and vowel type; and these numbers indicate the *magnitude of differences* triggered by each coarticulatory context. For Italian, these differences in means appear in Table 5.8. For example, in a comparison of coarticulatory effects on the F1 of target vowel /a/, we find that between the contexts /$\text{kaC}_2\text{aC}_3\text{V}_3$/ and /$\text{kiC}_2\text{aC}_3\text{V}_3$/ there is a difference of only -1 Hz; the negative value indicates that F1 of /a/ is *slightly higher* in the $V_1 = $ /a/ context than the $V_1 = $ /i/ context. Among the values for F2, differences are larger, which is expected partially because the range of F2 values is larger than that for F1. Bigger differences occur across V_1 contexts than V_3 contexts for F2; the biggest is for target vowel /u/, where the mean F2 is 62 Hz higher for $V_1 = $ /a/ than for $V_1 = $ /i/.

Table 5.8.   **Differences in Italian mean formant values across coarticulatory contexts: Preceding (V_1) and following (V_3) contexts (5 female speakers; non-normalized data)**

V_2	Italian - F1 Mean(a) - Mean(i)		Italian - F2 Mean(a) - Mean(i)	
	V_1	V_3	V_1	V_3
a	-1	-14	-15	-18
e	3	16	-44	-34
i	4	2	-19	-4
o	-15	6	-6	-10
u	2	1	-62	10

214

These magnitudes of difference are schematized in Table 5.9, which divides the total range of context-dependent differences into smaller pieces. In this table, the differences in means expressed numerically in Table 5.8 have been transformed onto a color-coded scale, where larger differences in means are indicated with darker shades of gray, as shown in the key to the right of the table. The table itself shows the Italian target vowel (V_2) space assumed in this experiment, arranged along parameters of height and backness, and each vowel has been shaded to indicate the difference in means found for a particular formant and coarticulatory contrast. Vowel spaces in the top half of the table indicate, from left to right, the effects of preceding (V_1) and following (V_3) vowels on mean F1 values; and vowel spaces in the bottom half of the table indicate the same information for mean F2 values. The arrows in this table indicate the direction of coarticulation: left-to-right for carryover ($V_1 \rightarrow V_2$) coarticulation, and right-to-left for anticipatory ($V_2 \leftarrow V_3$) coarticulation.

Table 5.9 shows, at a glance, that in Italian the differences across carryover and anticipatory vowel-to-vowel coarticulatory contexts vary depending on the *direction* of coarticulation, and on the target vowel. For F1, the greatest carryover effects are seen in the darker shading of /o/, which nonetheless represents a difference of only 15 Hz (seen in Table 5.8). The greatest anticipatory effects for that formant are in /e/ and /a/. For F2 the greatest carryover effects are on /u/, which is the darkest-shaded cell in the table, in the range of 51-150 Hz (and precisely 62 Hz as shown in Table 5.8 above).

Table 5.9. **Magnitude of coarticulatory vowel-to-vowel effects in Italian (5 female speakers)**

F1 Vocalic Effects - Italian				
$V_1 \to V_2$			$V_2 \leftarrow V_3$	
i		u	i	u
e		o	e	o
	a			a

Difference in F1
< 10 Hz
11-20 Hz
> 20 Hz

F2				
$V_1 \to V_2$			$V_2 \leftarrow V_3$	
i		u	i	u
e		o	e	o
	a			a

Difference in F2
< 25 Hz
26-50 Hz
51-150 Hz
151-200 Hz
> 200 Hz

Throughout the rest of this section, I present results using this pairing of data tables with shaded schematic tables. In all cases the calculations were made according to the techniques described above for Table 5.8 and Table 5.9. Next, I turn to a quantitative comparison of preceding and following vowel effects in Romanian.

5.5.3.2. Preceding and following vowel effects in Romanian

In this subsection I quantify the effects of differing coarticulatory vowel contexts on formant values in Romanian, both within and across carryover and anticipatory contexts. First, the data shown in Table 5.6 and Table 5.7 are distilled to show the differences in mean formant values across coarticulatory contexts. These differences are displayed in Table 5.10, for female speakers (male speakers' data appear in Appendix E). As described above, the results in this table are obtained by taking the difference in mean formant values for a given vowel in a particular pair of contexts; a negative value indicates a greater formant value when /i/ is V_1 (for carryover coarticulation) or V_3 (for anticipatory coarticulation).

Table 5.10. **Differences in Romanian mean formant values across coarticulatory contexts: Preceding (V_1) and following (V_3) contexts (8 female speakers; non-normalized data)**

V_2	Romanian - F1 Mean(a) - Mean(i)		Romanian - F2 Mean(a) - Mean(i)	
	V_1	V_3	V_1	V_3
a	-4	-9	-13	-28
e	-34	56	51	-181
ʌ	-38	19	-13	-39
ea	-13	1	17	-29
i	11	0	-9	-6
ɨ	3	5	-50	-88
o	-16	4	-20	10
oa	-10	-1	-12	-23
u	4	4	-37	-12

For Romanian F1, many values in this table are negative in the carryover context; this indicates that in fact, F1 *rises* when V_1 = /i/. This suggests that dissimilation may be occurring (as also described by e.g. Tilsen 2009), since in the case of assimilation *lower* F1 values are expected with /i/ than with /a/. Turning to F1 values when V_3 is the relevant factor, however, values are mostly positive, indicating either very small differences in means or the expected coarticulatory assimilation pattern. For F1, effects of V_1 tend to be larger than those of V_3 (e.g. /o/, /i/, /ʌ/), although the F1 of /e/ is more affected by anticipatory than carryover coarticulation.

The table shows that among F2 values, differences in means tend to be greater in anticipatory (V_3) contexts than in carryover contexts; this is particularly true for /e/, which shows a difference of 51 Hz in the V_1 context, but of -181 Hz in the V_3 context. This indicates a higher F2 before /i/, consistent with assimilation toward the following vowel. In F2, V_3 effects tend to be larger than V_1 effects; compare values for /a/, /ʌ/, /e̯a/, /ɨ/, and /o̯a/. This is consistent with the hypothesis that anticipatory vowel-to-vowel effects outweigh carryover effects in Romanian.

These differences in means are schematized using gradient shading of the Romanian vowel space in Table 5.11. Recall that F1 and F2 have different scales of shading, to reflect the relatively larger possible range of values in F2. In F1 in Romanian (unlike in Italian), there are carryover and anticipatory effects that exceed 20 Hz; these are found for /e/ in both contexts, and for /ʌ/ in the carryover context. Across carryover and anticipatory contexts, the magnitude of effects on F1 for /ɨ/, /u/, and /a/ remains small, indicating symmetrical coarticulatory effects in these contexts. Among F2 values, the biggest effects are again in /e/, and also in /ɨ/; the largest is for /e/ in the anticipatory (V$_3$) context, which lies in the 151-200 Hz range. Comparing the carryover and anticipatory effects on F2, shading tends to be darker in the latter case, reflecting the larger anticipatory effects seen above.

Table 5.11.   **Magnitude of coarticulatory vowel-to-vowel effects in Romanian (8 female speakers)**

Comparing the Italian and Romanian results seen in this subsection, one fact is striking: in Romanian, when a formant is affected by surrounding vowels, the magnitude of the effect is much greater than that in Italian. The biggest effect on F1 in Romanian, for target vowel /e/, shows more than a 50 Hz difference in the mean

values of F1 depending on the following vowel environment; in F2, the biggest difference is also for /e/, and is 160 Hz. F2 is expected to be more variable than F1, since it has a greater absolute range of values (approx. 800 – 2600 Hz vs. 300 – 900 Hz). By comparison in Italian, there is also an effect on the F1 of /e/, but it is an insignificant difference of less than 20 Hz; for F2, the biggest effect of a preceding vowel, on /u/, is significant but is only 62 Hz. It appears that Romanian vowels have wider phonetic ranges than Italian vowels, but this is not random variability; it is often attributable to coarticulatory effects, a characteristic explored in more detail in §5.6. This trend, in which the magnitude of differences across surrounding environments is much larger in Romanian than Italian, is also observed in the data focusing on consonantal environments.

5.5.4. Quantifying and comparing differences: Effects of surrounding consonants

This subsection explores the coarticulatory effects of consonants in Italian and Romanian. In other words, rather than looking at carryover and anticipatory vowel-to-vowel coarticulation, we now examine carryover and anticipatory consonant-vowel coarticulation. The target segment in this case remains V$_2$; the preceding consonant responsible for carryover coarticulation is C$_2$, and the following consonant, which triggers anticipatory coarticulation effects, is C$_3$. The consonants are /p/ or /tʃ/ in Italian and /p/ or /ts/ in Romanian.

The mean formant values for each vowel in both languages, in the two carryover coarticulation environments, are shown in Table 5.12. The methodology for creating this table is the same used to create similar tables for vowel-to-vowel effects, above. Within each language and vowel type, the mean measurements are divided into two categories: those in which the measured target vowel was preceded by [p], and

those in which it was preceded by either [tʃ] or [ts]; standard deviations for each

environment are also shown. Only female speakers' data are shown here, but male

speakers' data are summarized in Appendix D. In this table, for F1 in both languages,

there do not appear to be large differences in mean values across the two C_2 contexts.

In F2 differences are larger, on the order of 100 Hz for the F2 of Italian /e/ (2377 Hz

when C_2 = /p/, and 2276 Hz when C_2 = /tʃ/) or more than 160 Hz for the F2 of Italian

/u/. The differences are larger still in Romanian, for certain vowels such as /ʌ/, whose

F2 varies from a mean of 1347 Hz in the C_2 = /p/ context to 1600 Hz when C_2 = /ts/.

The directions of these effects are consistent with expectations based on the

articulatory and acoustic properties of labial vs. alveo-palatal consonants: the lip-

rounding necessary to produce /p/ causes a reduction in F2, which in the acoustic

vowel space corresponds to vowel backing.

Table 5.12.   **Mean formant values by preceding consonant (C_2): Female**

        speakers

	Italian – F1						Italian – F2					
	C_2 = /p/			C_2 = /tʃ/			C_2 = /p/			C_2 = /tʃ/		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	897	60	118	884	78	121	1439	146	118	1515	155	121
e	515	98	120	513	97	120	2377	201	120	2276	173	120
i	292	41	120	309	50	119	2673	75	120	2634	81	119
o	699	81	120	734	74	119	1070	115	120	1209	170	119
u	348	52	120	342	53	119	809	202	120	971	217	119
	Romanian – F1						Romanian – F2					
	C_2 = /p/			C_2 = /ts/			C_2 = /p/			C_2 = /ts/		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	872	105	192	874	101	191	1339	120	192	1481	151	191
e	574	56	191	567	55	191	2186	228	191	2160	196	191
ʌ	614	67	190	611	68	192	1347	142	190	1600	155	192
ea	877	93	191	869	92	190	1695	115	191	1710	153	190
i	324	40	192	337	42	189	2760	101	192	2704	115	189
ɨ	402	35	191	409	40	195	1418	203	191	1784	186	195
o	570	55	190	589	61	192	930	87	190	1085	90	192
oa	832	117	192	815	108	193	1235	104	192	1274	108	193
u	408	40	191	394	39	192	855	141	191	1080	193	192

Data from to anticipatory consonant-vowel coarticulation in Table 5.13 is divided into subsets based on the quality of C_3. As in the results for carryover articulation, we find only small differences in F1 means in both languages across the two C_3 contexts. Differences in F2 are larger, as expected given the expanded range of F2 relative to F1. In Italian, there are differences of more than 60 Hz across C_3 contexts, such as for /a/ and /e/; thus consonant effects are generally bigger than vowel effects. In Romanian, however, F2 values are more variable. For /a/, there is a difference of nearly 90 Hz across the two contexts, the mean F2 of /ɨ/ is 1498 Hz when C_3 = /p/, vs. 1706 Hz when C_3 = /ts/. This indicates greater magnitudes of effect across coarticulatory contexts in Romanian than Italian; in the following subsection, I quantify and compare these differences.

Table 5.13.   **Mean formant values by following consonant (C_3): Female speakers**

	Italian – F1						Italian – F2					
	C_3 = /p/			C_3 = /tʃ/			C_3 = /p/			C_3 = /tʃ/		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	893	66	118	888	73	121	1447	138	118	1508	165	121
e	525	104	121	503	89	119	2294	205	121	2359	177	119
i	305	49	119	297	44	120	2643	88	119	2664	70	120
o	714	80	118	719	79	121	1121	138	118	1158	178	121
u	346	54	121	344	51	118	842	184	121	939	251	118
	Romanian – F1						Romanian – F2					
	C_3 = /p/			C_3 = /ts/			C_3 = /p/			C_3 = /ts/		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	872	107	192	874	99	191	1366	150	192	1454	145	191
e	579	56	191	562	53	191	2160	224	191	2185	199	191
ʌ	619	71	192	606	63	190	1381	184	192	1569	158	190
ea	879	86	191	867	99	190	1674	141	191	1730	123	190
i	329	40	191	333	43	190	2747	112	191	2717	109	190
ɨ	403	40	191	408	35	195	1498	283	191	1706	204	195
o	581	59	192	577	59	190	971	112	192	1045	112	190
oa	817	114	193	829	111	192	1214	99	193	1295	101	192
u	400	42	192	402	38	191	863	160	192	1073	186	191

5.5.5. Comparison of preceding and following consonant effects

The comparisons in this subsection focus on a detailed examination of the magnitude of differences between means, as a function of vowel type and surrounding consonantal environment. I consider first the differences across coarticulatory directions and consonant types in Italian, and then turn to Romanian.

5.5.5.1. Preceding and following consonant effects in Italian

In order to understand the extent of consonant-vowel coarticulatory effects in Italian, we calculate the differences in means across the two consonant types (/p/ vs. /tʃ/), in both carryover (C_2) and anticipatory (C_3) coarticulation environments. These differences are calculated as described above for vowels in §5.5.3.1: I begin with the mean formant value (F1 or F2) in the /p/ coarticulatory context (i.e. C_2 = /p/ for carryover coarticulation, or C_3 = /p/ for anticipatory coarticulation) and subtract from it the mean formant value in the /tʃ/ coarticulatory context. Formulas are shown in (5.8) and (5.9).

(5.8) Carryover: [Mean(V_2) when (C_2 = p)] – [Mean(V_2) when (C_2 = tʃ)]

(5.9) Anticipatory: [Mean(V_2) when (C_3 = p)] – [Mean(V_2) when (C_3 = tʃ)]

The result of these calculations is a *difference in means*, specific for each comparison of C_2 or C_3 contexts, and the results for Italian appear in Table 5.14. In this case, a negative value indicates a *lower* formant value in the labial context than the affricate context. For F2 in particular, the lowering of a formant in the vicinity of a labial indicates context-induced vowel backing. Among F1 values in this table, there are slightly larger effects in the carryover (C_2) context than the C_3 context; and among F2 values, carryover effects are noticeably larger than anticipatory effects. The largest

effects, dependent on C_2 for /a/, /o/ and /u/, are all negative, indicating the difference in backness of vowels as a function of the preceding consonant. The anticipatory effects, while smaller in magnitude, all consistently indicate backing as a result of a following /p/.

Table 5.14. **Differences in Italian mean formant values across coarticulatory contexts: Preceding (C_2) and following (C_3) contexts (5 female speakers; non-normalized data)**

V_2	Italian - F1 Mean(p) - Mean(tʃ)		Italian - F2 Mean(p) - Mean(tʃ)	
	C_2	C_3	C_2	C_3
a	13	5	-75	-61
e	2	22	101	-65
i	-17	8	39	-22
o	-35	-5	-140	-37
u	6	2	-162	-97

The data from Table 5.14 are schematized using shading in Table 5.15. This table was constructed with the same techniques, and using the same scales for F1 and F2, as those shown above for vowel-to-vowel coarticulation. The differences in means expressed numerically in Table 5.14 have been transformed onto a color-coded scale, where larger differences in means are indicated with darker shades of gray, as shown in the key to the right of the table.

Table 5.15. **Magnitude of coarticulatory consonant-vowel effects in Italian (5 female speakers)**

F1 Consonantal Effects - Italian					Difference in F1
C$_2$ --> V$_2$		V$_2$ <-- C$_3$			< 10 Hz
i	u	i	u		11-20 Hz
e	o	e	o		> 20 Hz
a		a			

F2					Difference in F2
C$_2$ --> V$_2$		V$_2$ <-- C$_3$			< 25 Hz
i	u	i	u		26-50 Hz
e	o	e	o		51-150 Hz
a		a			151-200 Hz
					> 200 Hz

This table illustrates that the carryover (C$_2$) effects tend to be greater in magnitude than the anticipatory effects, especially for F1; in F2, the vowel most affected by carryover coarticulation is /u/, falling into the 151-200 Hz range of difference. Also in F2, we see that /i/ is little affected by either anticipatory or carryover coarticulation, while other vowels undergo a moderate amount of coarticulation in both contexts.

5.5.5.2. Preceding and following consonant effects in Romanian

A comparison of formant values across consonant-vowel coarticulatory contexts in Romanian is predicted to demonstrate, according to my phonologically-based hypotheses, that carryover coarticulation has a larger effect than anticipatory coarticulation. This subsection considers that hypothesis in a quantitative fashion. In Table 5.16 shows the differences in means across consonant types (/p/ vs. /ts/, for this language) in both the carryover (C$_2$) and anticipatory (C$_3$) coarticulation contexts. As elsewhere, the results are divided by formant and by target vowel (V$_2$) type, to

illustrate differences across those environments. Also as above, a negative value in this table indicates a lower value in the environment of a labial consonant. Recall that with regard to the phonological processes of Romanian, I hypothesized that the Labial Effect, in which front vowels undergo post-labial backing to central vowels, historically occurred as a result of increased vowel coarticulation with labials.

Table 5.16.   **Differences in Romanian mean formant values across coarticulatory contexts: Preceding (C_2) and following (C_3) contexts (8 female speakers; non-normalized data)**

V_2	Romanian - F1 Mean(p) - Mean(ts)		Romanian - F2 Mean(p) - Mean(ts)	
	C_2	C_3	C_2	C_3
a	-2	-3	-141	-87
e	7	18	26	-25
ʌ	3	13	-253	-187
ea	9	12	-15	-56
i	-13	-4	56	30
ɨ	-7	-5	-366	-208
o	-19	4	-155	-74
oa	17	-12	-39	-81
u	15	-3	-225	-211

In this table, effects on F1 are small (less than 20 Hz for all vowel types), indicating little effect of carryover or anticipatory coarticulation on this formant in Romanian. This is one area in which the magnitudes of difference seen in Italian outweigh those in Romanian. Turning to F2, however, the picture is very different: here, nearly all values are negative, indicating considerable phonetic post-labial backing. Comparing the differences in F2 across the carryover and anticipatory contexts, the means conditioned by C_2 are more disparate than when they are conditioned by C_3; for example, the size of the carryover effect for /o/ is twice as large as the anticipatory effect for that vowel (-155 Hz vs. -74 Hz). This table shows the

largest differences in means encountered thus far in the data analysis: consider the
carryover effects on the F2 values of /ʌ/ and /ɨ/, which are -253 Hz and
-366 Hz, respectively.

The relatively intense consonant-vowel coarticulation in Romanian is
summarized visually in Table 5.17. This shows the differences in mean formant values
on a shaded scale, in which a darker shade of gray indicates a greater difference in
mean formant values across consonant types within a particular comparison. Among
the results for F1, there are only small magnitudes of difference across coarticulatory
contexts; no difference in means exceeds 20 Hz. In F2, however, there are large
differences: in the carryover (C_2) context, three vowels exceed 200 Hz in their
differences between means; these are /ɨ/, /u/ and /ʌ/. In the anticipatory context, /ɨ/ and
/u/ continue to show this level of coarticulation.

Table 5.17. **Magnitude of coarticulatory consonant-vowel effects in**
Romanian (female speakers)

F1	Consonantal Effects - Romanian					
C_2 --> V_2			V_2 <-- C_3			Difference in F1
i	ɨ	u	i	ɨ	u	< 10 Hz
e	ʌ	o	e	ʌ	o	11-20 Hz
	a			a		> 20 Hz

F2						Difference in F2
C_2 --> V_2			V_2 <-- C_3			< 25 Hz
i	ɨ	u	i	ɨ	u	26-50 Hz
e	ʌ	o	e	ʌ	o	51-150 Hz
	a			a		151-200 Hz
						> 200 Hz

These data fit patterns seen elsewhere, namely that /ɨ/ and /ʌ/ exhibit large
amounts of variation depending on their consonantal frame (§5.1.2). Where /u/ is

concerned, it may be the case that since /u/ is the farthest-back vowel, its formants are the most affected by the different articulations required for /p/ and /ts/, the latter requiring a fronted tongue position farther from the default articulation for /u/ than for any other Romanian vowel. These results show one other interesting fact – namely, that the articulation of /e/ does not vary greatly depending on surrounding contexts, while it undergoes a greater amount of vowel-to-vowel coarticulation than other vowels do (see Table 5.11). This emphasizes the degree to which we should *not* expect coarticulation to be analogous or symmetrical across contexts, whether those contexts include target vowel types, direction of coarticulatory effect, or the type of trigger (consonant vs. vowel).

Overall, the results in this section show that stressed vowels undergo greater coarticulation with preceding consonants than following consonants, and that the magnitude of the effect is much larger in Romanian than Italian. This is consistent with the hypothesis that in Romanian, there are acoustic parallels of a phonological process like the Labial Effect, in which vowel backing is triggered by a preceding consonant. Additionally, these results confirm that consonant-vowel coarticulation tends to be of greater magnitude than vowel-to-vowel coarticulation; this is expected, due to the fact that the consonants are immediately adjacent to the vowels they affect, while the effects of V_1 and V_3 traverse the intervening consonants.

5.5.6. Statistical analysis

To complete the quantification of the relationship between target stressed vowels and the segments surrounding them, a mixed-effects statistical model was constructed to determine which factors significantly affected the formant values of target vowels. Since the experimental design was balanced, with identical numbers of stimuli in each condition, I am able to pool across the data set for increased statistical

modeling power. For any given parameter of interest, i.e. the effect of V_1 on V_2, the balanced design allows use of all the data rather than a less-powerful subset of it.

The model was constructed using normalized data, as described in §5.4 above, and in fact the model was run using the z-scores of formant values as the dependent variable, to maximally factor out effects of speaker-dependent variability. This technique was not used in many previous studies of coarticulation; the persistence of statistically significant effects here even after normalization indicates their robustness. The model included the following fixed effects: gender, preceding consonant (C_2), preceding vowel (V_1), following consonant (C_3), and following vowel (V_3). Additionally, the model included interaction terms between V_1 and C_2; and C_3 and V_3. It was necessary to include gender for reasons discussed in Chapter 4, namely that male and female speakers' vowel spaces have different formant ranges, a fact that affects even normalized data. Significant results for gender persisted in the model despite the normalization and z-score procedures undertaken to standardize the data across speakers; it is possible that the significance of this predictor remains because of the small numbers of male speakers. Finally, *word* was included in the model as a random factor.

The model was run separately on each formant (F1, F2), and each vowel, for each language; for example, the F1 z-scores of Romanian /e/ were modeled separately from those of Italian /e/. This separation within the modeling was done based on the fact that the descriptive statistics, seen in the previous sections, clearly demonstrate different coarticulatory tendencies across vowel types, and differences across formants and languages are also expected.

Other models were tested prior to selecting this format. For example, a model run only by formant and by language is inadequate; it finds significant interactions between surrounding environments and vowel type, which complicates interpretation

of the main effects. A test of a model of this type in fact found significant interactions in Italian F1 between vowel type and preceding ($p < .0001$) and following ($p = .0398$) consonants, and the same for F2 ([vowel*preceding consonant]: $p < .0001$; [vowel*following consonant]: $p = .0049$). For Romanian F1, the model found highly significant ($p < .0001$) interactions between vowel type and all four surrounding contexts; for F2, the same interactions were found with the exception of that between vowel type and preceding vowel, which was slightly less significant ($p = .0123$).

Pre-testing also determined that nearly all the variability in the overall F1-F2 acoustic space is attributable to vowel quality. In a model of F1 and F2 that predicted the formants' z-scores using a sole independent variable of vowel type, I found that in Italian, model fit for both formants approached $R^2 = 0.95$; for Romanian, the F1 fit was 0.95, and the F2 fit was 0.9. This means that at the most only 10% of formant variability remains unaccounted for once vowel type is controlled. By running each vowel separately, I effectively assume different F1 and F2 values for different vowels, and it is possible that what variability remains cannot be accounted for by the controlled predictors available in this experiment. This raises the possibility that in the models run below, some vowels will have no significant predictors.

5.5.6.1. Results

Across the models run for each vowel, great variation is found in the number and types of significant predictors. The tables below include summaries of the factors found to be significant, for each formant, for each vowel, in each of the two languages. These tables include a value for the random factor, *word*, which indicates the amount of variability present across words (stimuli) in the data set, expressed as a percentage of the total variability. A low value in that column means that little variability in the data can be attributed to variation across the nonce words used, and instead variability

in the data is more likely to be meaningfully attributed to the fixed effects. Each item

listed in the Predictor column of this table is a factor found to be significant ($p < 0.05$)

for the particular vowel listed in the Vowel column; and the corresponding t-statistic

and p-value appear in the two rightmost columns.

5.5.6.1.1. Modeling F1

In Italian, we find that in the proposed models for F1, a range of predictors is

significant, but except in the case of /a/ and /o/, at most one predictor per vowel is

significant. The most common significant predictor is the preceding consonant (C_2),

followed by gender; the following consonant (C_3) is significant only for /e/, and

preceding and following vowel (V_2, V_3) are not significant predictors.

Table 5.18.   **F1 in Italian**

Vowel	Word: % of total	Predictor	F-Ratio	p-value
/a/	0	C_2	$F(1, 341) = 11.6546$	0.0007
		Gender	$F(1, 341) = 5.5060$	0.0195
/e/	0	C_3	$F(1, 344) = 5.0741$	0.0249
/i/	1.22	C_2	$F(1, 9.29) = 14.0958$	0.0043
/o/	1.0	C_2	$F(1, 9.25) = 25.7632$	0.0006
		Gender	$F(1, 339) = 4.3972$	0.0367
/u/	3.85	*none*		

In Romanian there are multiple significant predictors for the F1 of several

vowels, although only one predictor is significant in the models for /a/, /ɨ/ and /o̯a/.

Both consonants and flanking vowels are often significant predictors (in Table 5.19);

in particular, the following vowel (V_3) is significant for /e/ and /ʌ/, while the

preceding vowel is more commonly significant (V_1 – for /e/, /ʌ/, /e̯a/, /i/, /o/). Thus

both with respect to the number of predictors that tend to be relevant for a given

vowel, and the types of predictors that are relevant, the Romanian results are different

from Italian. From these results, it appears that stressed vowels in Romanian more often coarticulate in *height* with a preceding rather than a following vowel.

Table 5.19.   **F1 in Romanian**

Vowel	Word: % of total	Predictor	F-Ratio	*p*-value
/a/	0.18	Gender	$F(1, 385) = 23.5247$	<0.0001
/e/	0	V_1	$F(1, 390) = 56.1243$	<0.0001
		C_3	$F(1, 390) = 16.4120$	<0.0001
		V_3	$F(1, 390) = 186.1649$	<0.0001
		Gender	$F(1, 390) = 13.8747$	0.0002
/ʌ/	0	V_1	$F(1, 390) = 83.4635$	<0.0001
		C_3	$F(1, 390) = 13.5197$	0.0003
		V_3	$F(1, 390) = 26.1329$	<0.0001
/ea̯/	0	V_1	$F(1, 384) = 8.7128$	0.0034
		C_3	$F(1, 384) = 16.2248$	<0.0001
		Gender	$F(1, 384) = 4.4587$	0.0353
/i/	0	C_2	$F(1, 387) = 12.2419$	0.0005
		V_1	$F(1, 387) = 12.4143$	0.0004
/ɨ/	5.37	Gender	$F(1, 385) = 14.3270$	0.0002
/o/	0.10	C_2	$F(1, 9.14) = 22.1100$	0.0010
		V_1	$F(1, 9.16) = 12.3427$	0.0064
/oa̯/	0.47	C_2	$F(1, 9.13) = 7.9621$	0.0197
/u/	0.52	C_2	$F(1, 8.85) = 20.9029$	0.0014
		Gender	$F(1, 386) = 9.9274$	0.0018

5.5.6.1.2.   Modeling F2

Turning to F2 in Italian, each vowel has at least two significant predictors: C_2 and C_3 are most often significant, and are generally highly significant. V_1 is also a significant factor for /i/ and /u/; and there is an effect of following vowel for /a/ and marginally for /e/, although additionally the interaction between following consonant and following vowel is significant for /e/. This means that there is a large effect of V_3 on F2, but that it varies with the quality of C_3; thus the main effect (V_3) cannot be

directly interpreted independent of the interaction term. This is the only vowel for which any interaction term is significant, across the data set.

Table 5.20.   **F2 in Italian**

Vowel	Word: % of total	Predictor	F-Ratio	p-value
/a/	0	C_2	$F(1, 341) = 51.4831$	<0.0001
		C_3	$F(1, 341) = 39.9710$	<0.0001
		V_3	$F(1,341) = 4.9127$	0.0273
		Gender	$F(1, 341) = 105.1280$	<0.0001
/e/	0	C_2	$F(1, 344) = 30.2293$	<0.0001
		C_3	$F(1, 344) = 12.9845$	0.0003
		(V_3)	$F(1, 344) = 3.7035$	(0.0551)
		C_3*V_3	$F(1, 344) = 7.2156$	0.0076
		Gender	$F(1, 344) = 5.2544$	0.0224
/i/	0	C_2	$F(1, 342) = 15.1843$	0.0001
		V_1	$F(1, 342) = 4.0099$	0.0460
/o/	0	C_2	$F(1, 347) = 180.4513$	<0.0001
		C_3	$F(1, 347) = 9.8780$	0.0018
		Gender	$F(1, 347) = 17.1568$	<0.0001
/u/	3.21	C_2	$F(1, 9.10) = 61.4491$	<0.0001
		V_1	$F(1, 9.12) = 6.1745$	0.0344
		C_3	$F(1, 9.11) = 24.7028$	0.0007
		Gender	$F(1, 334) = 5.0762$	0.0250

In Romanian, the results for modeling F2 show again that each vowel has at least two significant predictors; the most common is C_2, which is significant for all vowels but /ẹa/. C_3 is significant for seven out of the nine vowels; gender is significant for five; but V_1 significantly predicts only /e/ and /u/. Finally, V_3 is a significant predictor for seven vowels: /a/, /e/, /ʌ/, /ẹa/, /ɨ/, /ọa/ and /u/. For this predictor, no interactions are significant, indicating that when V_3 affects F2, it does so regardless of the intervening consonant (unlike in Italian). Generally, these results indicate that stressed vowels in Romanian coarticulate significantly in *backness* with the

consonants that both precede and follow them, but where vowel triggers are concerned, a following vowel is a more likely trigger than a preceding vowel.

Another interesting aspect of F2 in Romanian is the amount of variability given to the random factor *word* in this model. Elsewhere in the data set, this factor is found to account for little or none of the overall variability, but here it may be significant. For /ɨ/ in particular, 20% of the vowel's overall variability falls among the stimuli; and for both /i/ and /ɛ̯a/, that variability is over 6%. Where /ɨ/ is concerned, it is possible that the vowel's overall low frequency in Romanian and its generally high phonetic variability, combined with the fact that *none* of the vowel's typical phonological triggers are present in the stimuli, conspired to make these stimuli more difficult and thus more variable for speakers, and potentially less reliable as nonce forms representing possible phonological forms in Romanian.

Table 5.21. **F2 in Romanian**

Vowel	Word: % of total	Predictor	T-Ratio	*p*-value
/a/	2.57	C_2	$F(1, 9.36) = 140.1677$	<0.0001
		C_3	$F(1, 9.32) = 57.5404$	<0.0001
		V_3	$F(1, 9.33) = 5.1991$	0.0476
		Gender	$F(1, 384) = 4.2719$	0.0394
/e/	2.08	C_2	$F(1, 9.29) = 8.1360$	0.0184
		V_1	$F(1, 9.30) = 7.0524$	0.0255
		V_3	$F(1, 9.32) = 144.9333$	<0.0001
		Gender	$F(1, 382) = 42.5734$	<0.0001
/ʌ/	4.50	C_2	$F(1, 8.96) = 378.4444$	<0.0001
		C_3	$F(1, 8.96) = 182.7856$	<0.0001
		V_3	$F(1, 8.96) = 12.8267$	0.0059
/ɛ̯a/	6.20	C_3	$F(1, 8.84) = 8.4178$	0.0179
		V_3	$F(1, 8.85) = 7.1271$	0.0260
		Gender	$F(1, 375) = 150.7018$	<0.0001
/i/	6.24	C_2	$F(1, 9.50) = 11.6173$	0.0071
		Gender	$F(1, 380) = 229.4490$	<0.0001
/ɨ/	20.66	C_2	$F(1, 10.46) = 105.5557$	<0.0001
		C_3	$F(1, 10.46) = 35.0891$	0.0001

		V$_3$	$F(1, 10.52) = 6.6080$	0.0268
/o/	0.69	C$_2$	$F(1, 9.18) = 338.5223$	<0.0001
		C$_3$	$F(1, 9.15) = 78.9244$	<0.0001
/o̦a/	1.99	C$_2$	$F(1, 9.17) = 23.1799$	0.0009
		V$_2$	$F(1, 9.13) = 7.0207$	0.0261
		C$_3$	$F(1, 9.15) = 116.6654$	<0.0001
		V$_3$	$F(1, 9.17) = 7.8292$	0.0210
		Gender	$F(1, 387) = 89.5185$	<0.0001
/u/	0	C$_2$	$F(1, 394) = 317.0633$	<0.0001
		V$_1$	$F(1, 394) = 5.8379$	0.0161
		C$_3$	$F(1, 394) = 311.8487$	<0.0001
		V$_3$	$F(1, 394) = 4.3999$	0.0366

5.5.6.1.3.   Summary of statistics

The statistics presented above largely confirm the descriptive results presented in the figures shown in §5.5.2 - §5.5.5. While earlier studies (Öhman 1966; Manuel 1990; Beddor & Yavuz 1995) pooled coarticulation data without normalizing it, the present model finds statistically significant effects even after factoring out inter-speaker variability. This speaks to the robustness of the results.

Turning to the patterns of significant and insignificant factors for this data set, we find that in Italian, the majority of significant effects comes from consonants, and that for at least one formant (F2) both C$_2$ and C$_3$ significantly affect nearly all vowels. In Romanian there is significant consonant-vowel coarticulation in many cases, but also a wider variety of significant factors than in Italian, particularly with regard to V$_3$. This factor is significant for only the F2 of one vowel in Italian (marginally for a second vowel, although its effect is obscured by an interaction term), but it is significant for the F2 of seven out of nine Romanian vowels.

The overall picture that emerges, not only from these statistical models but also from the descriptive results, is that there is generally more variation of acoustic properties in Romanian than in Italian. Crucially, however, the statistical modeling shows that this variation can be attributed to specific coarticulatory sources, indicating

that it is not random variability. This is investigated in more detail in the next section. The robustness of these effects is additionally supported by the similarity of the results presented here with those found in the pilot study (§5.1), demonstrating that these results apply to both lexical words and nonce forms.

5.6.   Discussion

This study documents coarticulation of consonants and unstressed vowels onto stressed vowels. The above analysis has allowed multiple observations on the nature of coarticulatory effects, with the following experimental assumptions: first, cross-language comparisons are possible between Italian and Romanian. Secondly, this study allows direct comparison of carryover effects with anticipatory effects, and of consonant-vowel effects with vowel-to-vowel effects. Finally, this study assumes that coarticulation may not equally affect all vowel types, and thus examines each individually. In all comparisons, I have tested not only for the presence of coarticulatory effects, but also quantified the magnitude of these effects relative to one another. To summarize the findings, I present a collation of the schematics shown in §5.5.4 and §5.5.5 that demonstrates the magnitudes of difference across the different contexts available in this experiment. These appear in Table 5.22; vocalic effects for F1 and F2 are listed first, with Romanian on the left and Italian on the right; the bottom two sets of tables show the effects of consonant-vowel coarticulation for the two formants in both languages.

Table 5.22.   **Summary: Magnitude of coarticulatory effects (female speakers)**

Vocalic Effects - Romanian

F1

$V_1 \rightarrow V_2$			$V_2 \leftarrow V_3$		
i	ɨ	u	i	ɨ	u
e	ə	o	e	ə	o
	a			a	

F2

$V_1 \rightarrow V_2$			$V_2 \leftarrow V_3$		
i	ɨ	u	i	ɨ	u
e	ə	o	e	ə	o
	a			a	

Vocalic Effects - Italian

F1

$V_1 \rightarrow V_2$			$V_2 \leftarrow V_3$		
i		u	i		u
e		o	e		o
	a			a	

F2

$V_1 \rightarrow V_2$			$V_2 \leftarrow V_3$		
i		u	i		u
e		o	e		o
	a			a	

Difference in F1
< 10 Hz
11-20 Hz
> 20 Hz

Difference in F2
< 25 Hz
26-50 Hz
51-150 Hz
151-200 Hz
> 200 Hz

Consonantal Effects - Romanian

F1

$C_2 \rightarrow V_2$			$V_2 \leftarrow C_3$		
i	ɨ	u	i	ɨ	u
e	ə	o	e	ə	o
	a			a	

F2

$C_2 \rightarrow V_2$			$V_2 \leftarrow C_3$		
i	ɨ	u	i	ɨ	u
e	ə	o	e	ə	o
	a			a	

Consonantal Effects - Italian

F1

$C_2 \rightarrow V_2$			$V_2 \leftarrow C_3$		
i		u	i		u
e		o	e		o
	a			a	

F2

$C_2 \rightarrow V_2$			$V_2 \leftarrow C_3$		
i		u	i		u
e		o	e		o
	a			a	

Difference in F1
< 10 Hz
11-20 Hz
> 20 Hz

Difference in F2
< 25 Hz
26-50 Hz
51-150 Hz
151-200 Hz
> 200 Hz

This summary facilitates observations regarding the relative strength of coarticulatory forces. In Italian, carryover vowel-to-vowel coarticulation effects are larger than anticipatory vowel-to-vowel effects; in Romanian, the inverse tends to be true. Where consonant-vowel effects are concerned, both languages exhibit greater amounts of carryover than anticipatory coarticulation, but as in the case of vowel-to-

vowel coarticulation, the effects in Romanian are consistently of a greater magnitude than those in Italian. Across formants, effects on F1 are smaller than those on F2, which is expected due to the larger phonetic range available to the latter; and in many cases, the magnitude of consonant-vowel coarticulation is greater than vowel-vowel coarticulation. This is especially visible in the portion of Table 5.22 showing consonant-vowel coarticulation differences as expressed in F2. It is not a surprising result, since the consonants directly flank the target vowel, while V_1 and V_3 are farther away from it.

Table 5.22 also clearly shows that the magnitude of coarticulatory effects varies widely across vowel types. For example, while the F2 of Italian /i/ varies less than 25 Hz depending on the consonant that follows it, the F2s of Italian /e/ and /u/ vary between 51-150 Hz in that context.

In Romanian, the variation in magnitudes of anticipatory consonant-vowel coarticulation across vowel types may be indicative of the naturalness of phonological processes, which reinforces the link between phonetics and phonology, in the sense of e.g. Myers (1997), Cohn (1998) and Przezdziecki (2005). The stark contrasts in magnitudes of coarticulation between /e/ in the carryover vowel-vowel environment (in which the F2 of /e/ varies greatly) and in the carryover consonant-vowel environment (in which it varies very little) indicate a possible case of a phonetic and phonological doublet (Cohn 1998), a phenomenon in which we find both a categorically-defined phonological effect and a parallel, gradient phonetic effect.

In this case, the phonological effect is the Labial Effect, in which front vowels (/i/, /e/, /ea̯/) undergo backing to a central vowel when they are preceded by a labial consonant. In precisely the environment where we would expect to see large amounts of coarticulation to parallel that effect – that is, in the F2 of target vowels /e/ and /i/ – we find very little carryover coarticulation from a preceding consonant. However,

there is a large phonetic effect among vowels that do *not* undergo this phonological change: /ɨ/, /ʌ/ and /u/ all show a large amount of F2 reduction (backing) following the labial /p/ compared to the alveolar /ts/. This contrast is illustrated in the bottom row of tables within Table 5.22. Phenomena such as these doublets are taken as evidence that phonetics and phonology are linked, and that the latter can emerge from patterns in the former; however, the two types of processes are not equivalent, and must be considered separately in our models of the phonetics-phonology interface.

A visualization of the crucial data is provided below in Figure 5.13 and Figure 5.14, which compare coarticulation in Romanian and Italian in a single limited phonological context. Each shows a context in which the Romanian results parallel the phonology, while the Italian results show much smaller coarticulatory effects. In Figure 5.13, we see the mean F1-F2 values for female speakers of each language, as taken from tokens of /atsVtsa/ vs. /atsVtsi/ (in Italian, /atʃVtʃa/ vs. /atʃVtʃi/): this context shows the effects of anticipatory vowel-vowel coarticulation. Comparing the distance between the pairs of Italian data points (shown with circles) and the Romanian pairs (triangles), we see that the difference in means across Romanian contexts is often much larger than their Italian counterparts, particularly for /e/.
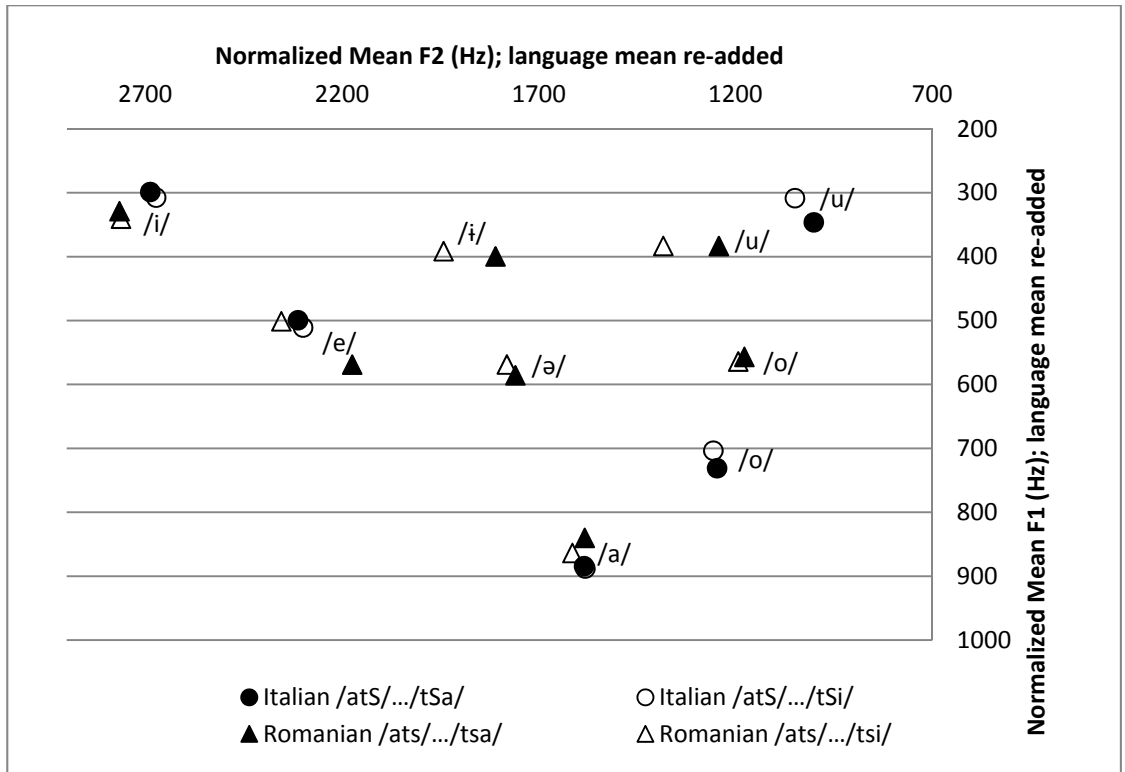
Figure 5.13. **Anticipatory VV coarticulation (/atsVtsa/ vs. /atsVtsi/): Romanian and Italian female speakers; normalized data.**

Figure 5.14, on the other hand, shows the mean F1-F2 values for female speakers of each language, as taken from tokens of /apVtsa/ vs. /atsVtsa/ (in Italian, /apVtʃa/ vs. /atʃVtʃa/). In this subset of the data C$_2$ alone alternates between a labial and a postalveolar or palatal affricate, showing the effects of carryover consonant-vowel coarticulation. The effects of carryover coarticulation are larger in Romanian (indicated by diamonds), particularly for /ɨ/, /ʌ/, and /u/; with the exception of /e/, the Italian means vary little by comparison.
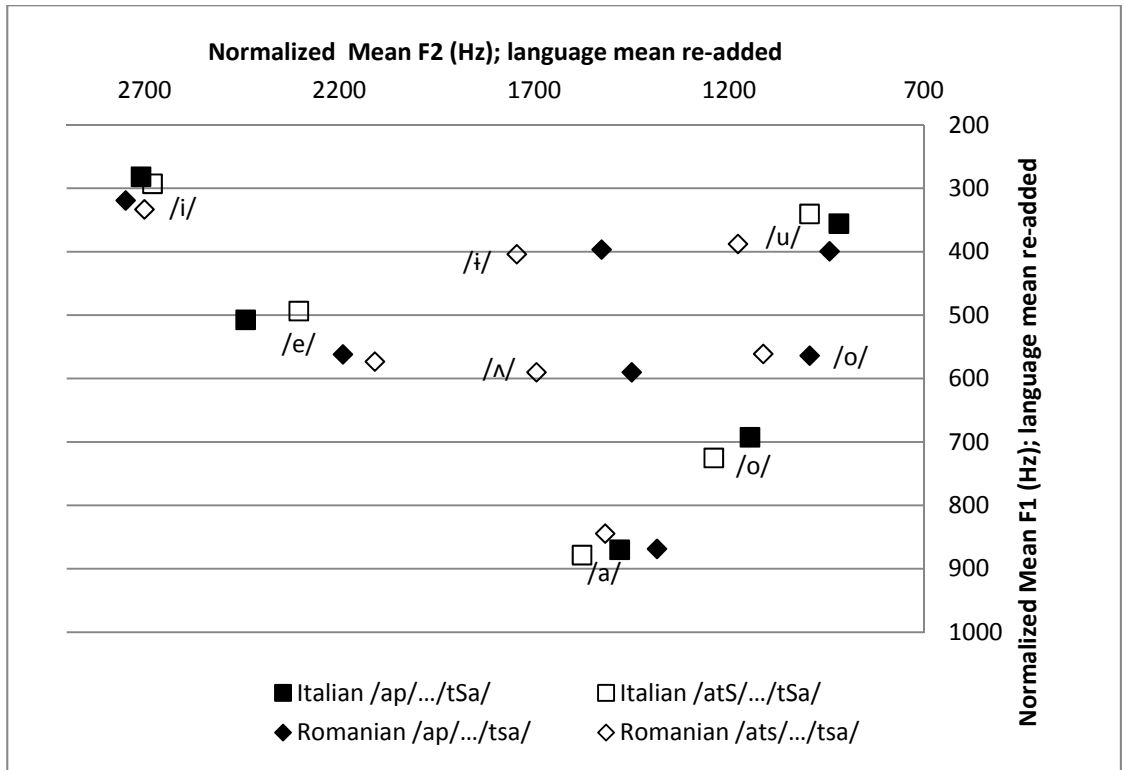
Figure 5.14. **Carryover CV coarticulation (/apVtsa/ vs. /atsVtsa/): Romanian and Italian female speakers; normalized data.**

5.6.1. Evaluation of hypotheses

Turning to the evaluation of hypotheses, I predicted as a null hypothesis that Italian would show symmetrical amounts of carryover vs. anticipatory coarticulation. Results show that especially as realized in F2, carryover effects in Italian are larger than anticipatory effects. This tendency holds for both vowel-to-vowel and consonant-vowel patterns, but its degree also varies by target vowel type. With regard to my original hypotheses about the potential for parallels between Romanian phonology and phonetics, these results provide positive evidence in their favor, although they are not uniform across vowel types. I hypothesized, based on pilot data, that the effect of anticipatory vowel-to-vowel coarticulation would be greater than that of carryover

coarticulation. This was verified, especially for /e/ and /i/, both of which participate actively in phonological alternations in Romanian.

Conversely, I predicted that where consonant-vowel coarticulation is concerned, carryover effects should outweigh anticipatory effects; this was also verified, particularly for /i/ but also in the raw differences in means for /i/, /ʌ/ and /u/ (see Table 5.16). While this tendency also holds for consonant-vowel coarticulation in Italian, it is important to recall that the magnitude of coarticulation is much greater in Romanian than Italian, reaching differences of more than 350 Hz in means across C_2 types. This result offers evidence for a phonology-phonetics link; if we assume that the levels of coarticulation in Italian indicate a kind of 'baseline' level of coarticulation, we see that in Romanian, the magnitude of coarticulation soars above this baseline in many contexts. Since the study contains stringent controls, and is comparing two related languages, I infer that Romanian's phonological processes are responsible for the exaggeration of these coarticulatory effects.

These results are consistent with the hypothesis that coarticulation in Romanian, but not in Italian, is exaggerated in ways that are consistent with the type of cue amplification that could eventually lead to phonologization of new alternations. Romanian exhibits this type of alternation, but Italian does not. In fact in Romanian, each context in which a coarticulatory factor significantly influences target vowels' acoustics is also relevant in historical vowel changes or synchronic phonological alternations of stressed-vowel quality. Preceding consonants affected stressed vowels as part of the Labial Effect, such as in *văr* [vʌr] 'cousin' from Latin *verus*; and one set of conditioning environments for central vowels /ʌ/ and /i/ were /e/ and /i/, respectively, after /r/, such as Latin *reus* → Romanian /rʌu/ 'bad' and *rivus* → /riu/ 'river.' Following consonants were relevant for the emergence of /i/, especially through pre-nasal raising (which in fact triggered */a/ → /i/, */e/ →/i/, and */o/ → /u/).

However, I know of no examples of obstruent segments like /ts/ affecting preceding vowels. Finally, following vowels are relevant for metaphonic processes in Romanian, in which stressed low vowels surface as mid vowels when followed by /i/ (in the case of /o̯a/, /a/) or /e/ (in the case of /e̯a/).

In standard Italian, on the other hand, these processes are not present. Vowels rarely alternate in Italian, and when they do, the alternation is usually stress-based (i.e. diphthongization under stress), but not triggered by segmental context. In the sense that surrounding segments are relevant for the phonology of Romanian more than for Italian, the results of this experiment parallel the phonological systems of the two languages.

5.6.2. Cross-language variability and implications for theoretical models

Throughout this chapter, I have referenced the intuition that Romanian and Italian may have different rates of variability, meaning that the two languages adhere to acoustic targets with differing degrees of precision. Based on visualizations of the data seen so far, it has seemed that Romanian vowels were more variable in their realizations, using wider ranges of formant values and perhaps having larger standard deviations than their Italian counterparts.

In this subsection, I demonstrate that in fact, we are seeing systematic differences in variation rather than random variability. It is crucial to take coarticulatory context into account when comparing variability in these two languages, and this finding is relevant for current models of the relationship between the size of a language's vowel inventory and the amount of coarticulation permitted by that language. Recall that as described in §5.2.1, I assume for the purposes of inventory comparison that Romanian and Italian both have seven-vowel systems. However, it is also possible to assume that Romanian has a larger inventory than Italian (nine vowels

242

vs. seven, or as few as five), in which case the predictions discussed below become more interesting in the face of my experimental results.

Research into the relationship between the size of languages' vowel inventories and their phonetic realizations has given rise to several theoretical models which generalize about the acoustic shape and space of vowel systems, including the role of coarticulation and variability. One such model is Adaptive Dispersion Theory (Liljencrants & Lindblom 1972; Lindblom 1986), which has two specific predictions regarding the relationship between vowel phoneme count and the acoustic vowel space. First, ADT predicts *sufficient dispersion*: that as the number of vowels increases, the vowel system itself should occupy more of the available acoustic space; thus, a language with fewer vowel phonemes should occupy a smaller range of acoustic space. If Romanian and Italian have equivalent spaces, they should have comparable amounts of dispersion; alternatively if the diphthongs are included for Romanian, I predict greater dispersion in that language.

Based on my experimental findings, Romanian exhibits greater dispersion along one acoustic dimension, as is seen for example by comparing Figure 5.11 and Figure 5.12. The data for speaker RoF1 occupy a range of roughly 300 Hz to 1000 Hz (F1) and 500 Hz to 3000 Hz (F2); those for speaker ItF1 range from approximately 250 Hz to 1000 Hz (F1) and 500 Hz to 2750 Hz (F2). This indicates that in terms of the second formant, the acoustic space of Romanian is 250 Hz larger than that of Italian (although its F1 space is slightly smaller). Since the difference is small, it does not strongly counterindicate the expectation of equivalent dispersion in two seven-vowel systems; but the direction of the disparity also fits with a treatment of Romanian as a larger system. In the literature we find other results consistent with this predicted relationship between inventory size and acoustic dispersion; Bradlow (1993)

reports that the larger phonemic inventory of English occupies more acoustic space than the five-vowel inventory of Spanish.

However, the ideas of ADT are also used to predict that inventory size should correlate inversely with variability: languages with *smaller* numbers of vowels should have *higher* variability, within each individual vowel, than a language with a greater number of phonemes. Much of this work is based on Manuel's (1990) paper, which purports to show that the vowels of two five-vowel Bantu systems have greater variability than those of a seven-vowel Bantu system. Manuel measured anticipatory vowel-to-vowel coarticulation by comparing F1 and F2 values with different following-vowel contexts. She sampled vowels at their mid and endpoints and hypothesized that a) "languages will tend to tolerate less coarticulation just where extensive coarticulation would lead to confusion of contrastive phones", and b) that languages with fewer vowels will tolerate more coarticulation (Manuel 1990:1286). Her data, based on only three speakers from each language, seem to show that the five-vowel systems have a greater spread in F1 and F2 values for /a/, depending on the following vowel.

However, Manuel's investigation appears problematic for several reasons: first, her figures and data are not normalized and often average across tokens (with different stress characteristics) and speakers, and the source of coarticulation is sometimes unclear. Additionally, her major prediction that the vowels in the five-vowel systems should "encroach" upon the acoustic space left available by their lack of phonemes is not verified by either language. While I assume the null hypothesis that Italian and Romanian should show equivalent amounts of variability and coarticulation, the fact that the languages clearly differ in terms of the latter calls into question these predictions of articulatory output constraints.

According to proponents of this strong version of ADT (Recasens & Espinosa 2006), a language with fewer phonemic vowel categories may expand, through acoustic variability, to "fill" the available acoustic space, while a language with more vowels must have relatively less variability because its acoustic space is expected to be more crowded. Other studies, it must be noted, have not found the expected differences in variability (Jongman, Fourakis & Sereno 1989; Bradlow 1993; Bradlow 1996; Beddor, Harnsberger & Lindemann 2002).

Under ADT and the predictions of Manuel (1990), in the highly-controlled stimuli of my experiment, I expect to find equal amounts of variability in Italian and Romanian vowels' formant values if both have seven-vowel systems. At this point, I use the results of my research to consider precisely this question: Which language exhibits greater variability?

To determine whether Italian or Romanian exhibits greater variability, I factor out any variation attributable to differing sources of coarticulation by limiting the analysis to a subset of the data. I compare the standard deviations of vowel formants (F1 and F2) in Italian vs. Romanian for target vowel tokens in which the only flanking consonants are affricates, and the preceding and following vowels are identical to one another. In other words, $C_2 = C_3 =$ /ts/ for Romanian and /tʃ/ for Italian; and $V_1 = V_3$, and the data is split by this parameter (flanking vowels are either /a/ or /i/, to gain more data points and test whether the effect depends on the flanking vowels' quality). Data was analyzed for female speakers only. The results for F1 are shown first, in Figure 5.15. In this figure, each bar represents the standard deviation of measurements for the first formant, for a particular vowel, in the restricted consonantal frame. On the left side of the figure, we see standard deviations for targets whose flanking vowels (V_1 *and* V_3) were /a/; on the right side, each target vowel was flanked by /i/. By restricting the analysis to these small subsets of data, I am effectively factoring out any

variability that could be due to combining data from different coarticulatory contexts (i.e. words with different segments).

This figure compares the size of the standard deviations in Italian and Romanian, for each vowel that occurs in both languages. Figure 5.15 shows in fact that variability (as measured via standard deviation size) is greater in Italian than in Romanian, in all but three cases (/u/ in the /a/ context, and /e/ and /o/ in the /i/ context). This indicates that contrary to the predictions of ADT, when coarticulatory context is controlled, Italian actually has greater variability than Romanian.
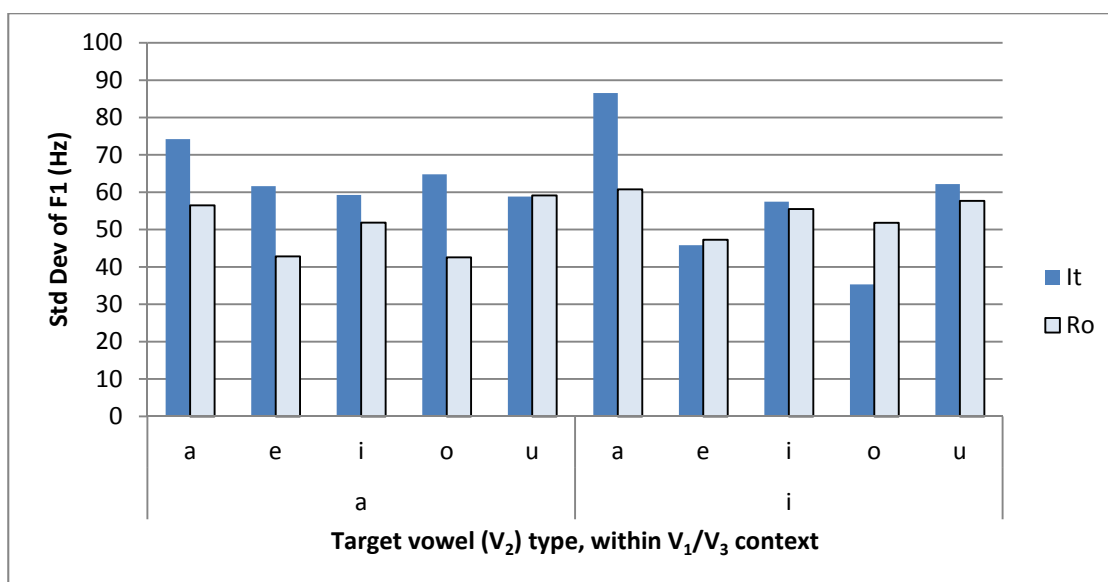
Figure 5.15.   **Standard Deviation of F1 (Hz) in Romanian and Italian. Normalized data; $C_2 = C_3 =$ affricates; $V_1 = V_3$; female speakers.**

Similar findings are reflected also in the standard deviations for F2 values, seen in Figure 5.16. Among target vowels flanked by /a/, three out of five show greater variability in Italian than in Romanian, and the remaining two (/a/ and /i/)

246

show equal variability in the two languages. Among those flanked by /i/, all but one (/u/) shows a greater standard deviation in Italian.
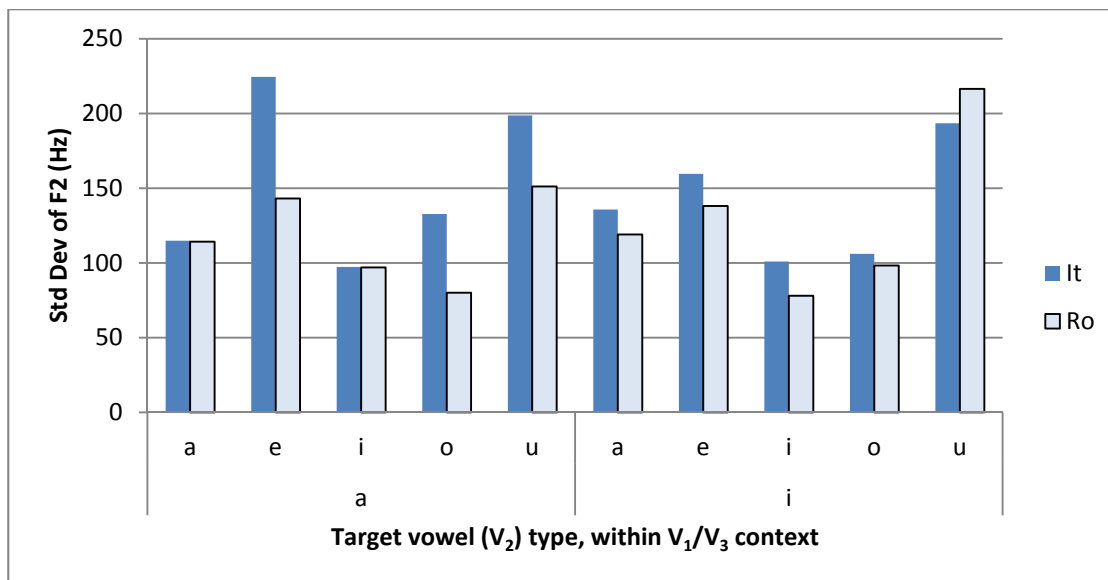
Figure 5.16.　**Standard Deviation of F2 (Hz) in Italian and Romanian. Normalized data; $C_2 = C_3 =$ affricates; $V_1 = V_3$; female speakers.**

The results in Figure 5.15 and Figure 5.16 were subjected to various statistical analyses, which failed to find significant differences in the size of these standard deviations across the two languages. The lack of significant difference is likely due to the necessarily small size of the data set: due to the segmental restrictions in place, each standard deviation measure (i.e. a single bar in the figures) is maximally composed of 24 observations. However, the tendency is clear: When coarticulatory context is taken into account, Italian has *higher* variability than Romanian.

The initial assessment of the data, without further contextual controls, seemed to demonstrate that Romanian vowels spread across wider swaths of acoustic space than their Italian counterparts. By taking into account the large coarticulatory effects

in Romanian, I have shown that this is not the case. By analyzing a controlled subset of the data, much variability in Romanian is removed, but the same subset in Italian now has greater variability. This suggests that while Romanian overall uses larger chunks of the F1/F2 space, that space is in fact apportioned depending on the segmental context in which a vowel occurs: the effects of coarticulation do not produce chaos, but rather separate the acoustic space into smaller, systematic pieces. Romanian shows not greater variability, but rather greater systematic variation.

This finding is both in agreement and conflict with those of Manuel (1990), whose findings imply that languages with equally sized inventories should exhibit equivalent amounts of coarticulation. This is explicitly shown to *not* be the case: more coarticulation occurs in Romanian than Italian. However, Manuel also predicts that "languages will tend to tolerate less coarticulation just where extensive coarticulation would lead to confusion of contrastive phones" (1990:1286). My analysis of the coarticulatory data does not necessarily argue against this: If the effects of coarticulation in Romanian result in systematically different acoustic realizations for vowels under different coarticulatory circumstances, then the "confusion of contrastive phones" may not be at stake. Listeners may perceptually account for the coarticulatory context even when acoustic overlap occurs between vowels.

The data I have presented demonstrate the necessity of distinguishing between two types of variability. The first is *context-dependent variability*, which is triggered by different coarticulatory contexts and is therefore somewhat predictable. The second is *context-independent variability*, which is a measure of the precision with which the phonetic realizations of vowels reach their acoustic target. With regard to the former, I have found an unexplained asymmetry in these two equivalently-sized vowel systems: Italian shows greater variability than Romanian. However, in quantifying context-*dependent* variability, which takes coarticulatory context into account, I find the

reverse: Italian exhibits less coarticulation than Romanian. If we instead assume asymmetrical inventory sizes, where Romanian has a larger inventory than Italian, then the data partially match Manuel's predictions: Italian, with its smaller vowel inventory, shows greater context-independent variability. But considering context-dependent variability in that case, the data conflict with Manuel's predictions based on inventory size: Italian permits less coarticulation than Romanian.

Faced with these conflicting results, I return to the fact that these two languages have different sets of active phonological processes; specifically, Romanian exhibits vowel metaphony (and consonant-based alternations) while Italian does not. Since all other factors have been strictly controlled in this study, I argue that these phonological distinctions underlie the different outcomes in the face of Manuel's predictions. Rather than relying simply on the size of a vowel inventory to predict levels of coarticulation, a model of vowel space and variability should also take into account the presence of phonological processes that may be directly tied – either historically, synchronically, or both – to coarticulatory effects. By considering both these elements, our model may be able to account for a greater range of data, and thus explain more patterns seen across the world's languages. Such a revision may be supported by Bradlow's (1993) result that Spanish vowels are *not* more tightly clustered than English vowels, despite the disparity in size of their vowel systems. She concludes that "the tightness of within-category clustering is not dependent on the size of the vowel inventory" (Bradlow 1993:37) in her study of these two languages which, like Italian, do not have active phonological processes of the type found in Romanian.

5.7.   Conclusions

Through pilot data (§5.1) and a tightly-controlled comparison of coarticulatory effects on stressed vowels in Italian and Romanian (§5.5), this chapter has shown the

range of variation found between two related languages, in terms of factors including target vowel type, consonant-vowel vs. vowel-vowel coarticulation, and anticipatory vs. carryover coarticulation. The results have demonstrated systematic and large differences across these contexts and across the two languages. Due to the experimental controls and comparability of Italian and Romanian, I have linked these contrasts to phonological differences between the two languages, including the size and shape of their vowel inventories and the phonological processes active in each. Specifically, this study has found evidence in Romanian for increased anticipatory vowel-vowel coarticulation in the environment of metaphony, and for increased carryover consonant-vowel coarticulation in the environment of post-labial centralization.

Additionally, the contrasts in vowel variability between Italian and Romanian call into question Manuel's (1990) proposal of the link between inventory size and variability. I instead propose that a model of vowel space and the variation within it should take into account the influence of language-specific phonological processes. This allows systematic coarticulatory differences to be factored out when evaluating variability. Once this is done, the differences in variability between Italian and Romanian counterindicate the proposal that inventory size should correlate inversely with coarticulatory effects.

The data showcased in this chapter show large acoustic distances between the vowels of Italian, and overlap or close adjacency in Romanian, particularly in the mid vowels. This study is restricted to only two surrounding vowel and consonant contexts; however, in natural speech involving the full consonant and vowel inventories as flanking contexts, both languages probably have increased variability in their vowels with respect to what is seen here. In Romanian, for instance, the acoustic spaces of each vowel type would certainly overlap – and yet speakers still

250

communicate effectively. Manuel's (1990) results, and those of ADT, could not adequately explain this phenomenon. While some empirical tests of the predictions of ADT have acknowledged the role of phonological and historical processes in shaping the overall dispersion rates of a language's vowel system (Lindau & Wood 1977; Disner 1983), the relevance of these factors for the coarticulatory properties of a language has not been factored into an ADT-style model.

The present result is more in line with the conclusions of Beddor et al. (2002), who, like Manuel, study Shona in comparison with English, and argue that in a vowel identification task listeners actively use their native knowledge of coarticulatory patterns. This suggests that listeners effectively take into account the vocalic and consonantal context and either use or factor out coarticulatory information. As speakers learn their native language, they quickly attune to its particular phonetic realizations, narrowing their range of production and perception to what is necessary for perceiving the language's phonological categories. This learning technique additionally provides a pathway for listener-driven development of phonological alternations based in coarticulation (Beddor, Harnsberger & Lindemann 2002; Narayan, Werker & Beddor 2010; Beddor, Krakow & Lindemann 2001).

Recent perceptual work on French (Nguyen, Fagyal & Cole 2004) has found that listeners responded more quickly to cross-spliced stimuli in which the coarticulatory vowel contexts matched than when they did not. In this study and those mentioned above, coarticulation is found to have significant effects on target vowels, but the net effect is a gradient rather than categorical phonetic effect. In the results of the present experiment, many significant coarticulatory effects (particularly in Romanian) exceed the minimum threshold for a just-noticeable difference of 25 Hz for F1 and 60 Hz for F2 (Flanagan 1955). This suggests that in some contexts, the gradient coarticulation found in Romanian and Italian stressed vowels could be

detected by listeners. In a perceptual experiment, a topic for further research, I predict that Romanian listeners would make more use than Italian speakers of coarticulatory information, which might be reflected in their reaction times to a set of cross-spliced stimuli.

CHAPTER 6: CONCLUSIONS

6.1.   Overview

This dissertation has investigated the Romanian vowel system from historical, phonological, and phonetic angles in order to deepen our understanding of the factors that influence both the shaping of a phonological inventory over time, and the interactions among its elements within the synchronic system. Romanian is the only Romance language with two central vowels (/ɨ/ and /ʌ/) in its inventory, and it exhibits typologically-rare diphthongs /e̯a/ and /o̯a/. Its unusual inventory thus provides an interesting case study. Additionally Romanian is under-studied with respect to the other Romance languages, meaning that the data collected here represent a significant new contribution to our descriptive knowledge of the language.

This chapter highlights the central findings of the dissertation by thematically contextualizing its most important results in terms of several topics of theoretical interest. I first reflect on the typological properties of Romanian which set it apart from other Romance languages, and the ways in which the historical development of Romanian is linked to linguistic concepts of the relationship between diachrony and synchrony (§6.2). A second major theme of the dissertation is marginal contrastiveness (§6.3); Romanian offers several examples of phonological gradience of this type. Given my acoustic and perceptual research results, I view marginal contrastiveness from several angles and consider how to continue our investigations of it. The range of factors shown to influence marginal contrastiveness and phonemic status in Romanian is complex, and they interact. To support making observations about the phonological system as a whole, instead of limited pairwise comparisons, I propose a new model identifying the parameters that should be considered to determine the overall phonemic robustness of a sound. In the dissertation, we have

253

also seen several manifestations of the strong position of morphological alternation in Romanian: it plays a role in determining the distributions of marginally-contrastive phonemes, and also (together with phonology) anchors phonetic processes such as coarticulation (§6.4). A final overarching issue linking the experimental results of this dissertation is the nature of the phonetics-phonology interface (§6.5, §6.6). In the remainder of this chapter, each of these interwoven themes is explored, and the discussions are interleaved with directions for future research.

6.2. Links between synchrony and diachrony

As described in Chapter 1, Romanian is typologically unique among Romance languages in its use of two central vowels, /ɨ/ and /ʌ/, and in its employment of diphthongs /e̯a/ and /o̯a/. In Romanian there is considerable evidence for the role of historical linguistic processes in shaping diachronic aspects of the system. This is true for many languages, but in Romanian the historical influence and interaction of varying factors, such as borrowings and phonological processes, is particularly transparent. While we do not know the history of Romanian with as much recorded detail as is available for other Romance languages, we know the general history of the area and its people, and the sequence of socio-political influences it experienced; scholars have used these to reconstruct the language's historical changes.

From a linguistic perspective, the structural differences between the native vocabulary and subsequent additions to the language are clear enough that it is straightforward to distinguish the four major strata of words: native words, and borrowings from Slavic, from Turkish, and recent Romance borrowings. These loanwords constitute a large portion of the Romanian lexicon, and they have not been phonologically adapted or altered to the extent that their origins are no longer recognizable. Romanian allows a range of phonological structures, and additionally its

phonological processes are often limited to a particular (historically-determined) stratum. For example, Romanian allows more syllable-final consonant clusters and prosodic word shapes than a language like Italian, and this has permitted Romanian to incorporate Slavic borrowings with minimal adaptation. An example of a lexically-stratified phonological change is the /b – w/ merger, which applied only to native Latin vocabulary: the most recent Romance loanwords do not show this change; thus a comparison of two Romanian forms with their etymons helps to date them relative to one another.

The language's orthographic system may boost transparency in some ways: it has a largely one-to-one correspondence between phonemic structure and the orthographic characters. This is largely due to the fact that Romanian orthography was codified late in the language's development, after many systematic historical changes had ceased to be active. There is thus a good match between the orthography, the phonology, and the historical forms of Romanian lexical items. Many scholars have leaned heavily on historical phenomena in seeking explanations for the synchronic state of the language, and as described in Chapter 1, most earlier work on Romanian emphasized historical change. One motivation for this focus may lie in the academic culture in which most early scholars worked: Romanian was (and still is in some communities) neglected as a Romance language, and thus many scholars worked to justify its classification and historical pedigree.

While historical investigation is invaluable for tracing the origins of languages and exploring the extent of possible linguistic variation, a language is also a synchronically functioning system, and the relations among its members merit investigation. As pointed out by Hyman (2008) in his discussion of linguistic universals, if diachrony were responsible for all the patterns we find, then none of the typological universals we in fact observe would occur. Diachrony is useful for

explaining typologically unusual properties in a language, for example from the perspective of Evolutionary Phonology (Blevins 2004; 2006). It is the synchronic system, however, that places constraints on what types of properties a language must have (Greenberg 1966; Hyman 2005). As we have seen in discussions of vowel space typology, Romanian does not exhibit seriously rare qualities: while its vowel system has evolved differently from those of other Romance languages, the synchronic system is symmetrical and contains a typologically-expected set of vowels in its seven-member system.

While a diachronic approach helps us understand *how* the Romanian vowel system arrived at its properties, in a mechanical sense and in comparison to other Romance languages, we do not need to appeal to diachrony to make sense of any irregularities.

6.3.   Characterizing and modeling marginal contrastiveness

Romanian allows us to view marginal contrastiveness from a phonological, acoustic and perceptual point of view. In this section I review the characteristics of marginal contrastiveness in Romanian, and suggest directions for future study and modeling.

The Romanian phonological inventory has marginally-contrastive phonemes which share some properties and not others: /ɨ, e̯a, o̯a/ all have very low type frequency, and their distributions can be largely described with a small set of environments. Also, all three appear in loanwords from various sources and these make up a large portion of wordforms in which the vowels appear. However, the marginal contrastiveness of /ɨ/ stands in relation to a single other phoneme (/ʌ/) and can be captured in terms of their respective phonological contexts, while that of /e̯a,

o̜a/ is based in morphology. Thus these three phonemes illustrate two different types of marginal contrastiveness, an idea developed below.

The marginal contrastiveness of diphthongs /e̜a/ and /o̜a/ is characterized not in terms of a minimal opposition within a pair of sounds, but rather in terms of their predictability across the lexicon. These two vowels have been incorporated, originally through phonological conditioning, into a myriad of morphological markers, to the extent that over 75% of instances of either fall into a small set of environments which have some phonological regularities and in some cases are contextually predictable. These diphthongs appear rarely enough that their features are little used in a purely distinctive capacity, that is in minimal pairs whose lexical difference is denoted by a single change of a distinctive feature (Jakobson, Fant & Halle 1963). However in their role within larger units, such as morphological endings, these vowels (/e̜a/ to the greatest extent) do have a more extensive role of specifying meaning.

The central vowels /ɨ/ and /ʌ/, on the other hand, are separate phonemes but contrast only marginally with each other: /ɨ/ in over 90% of cases remains restricted to the contexts in which it was originally phonologically conditioned (stressed and/or pre-nasal position). These are precisely the contexts in which /ʌ/ tends not to appear, instead falling in unstressed word-final position nearly 50% of the time (Chapter 3).

Acoustically, /ɨ/ and /ʌ/ are distinct from one another: they do not overlap with one another to a greater degree than they overlap with other adjacent vowels such as /a, e, o/ (for /ʌ/) or /u/ (for /ɨ/). Durationally, they pattern with other full monophthongs. Where the mid central vowel is concerned, the data in Chapter 4 support its transcription as a full vowel /ʌ/ rather than as /ə/, which typically denotes a reduced vowel. Perceptually, /ɨ/ and /ʌ/ seem to be distinguished with a high degree of success, with confusion rates only slightly higher than those for robustly phonemic /e/. Perceptual results show specifically that /i/ is identified with near-perfect accuracy; /ɨ/,

/e/ and /ʌ/ are identified with slightly less precision (Appendix C). Out of all four vowels /ʌ/ is the most readily confused, and is most often misidentified as /ɨ/. The precise motivation for this apparent one-way confusion has yet to be identified, but it does offer potential support for the presence of perceptual correlations with phonological marginal contrastiveness.

6.3.1. Testing phonemic independence

One question addressed by this dissertation is the synchronic status of /ɨ/: while it is categorized as a phoneme due its presence in minimal pairs, particularly with its former allophone /ʌ/, evidence from its distribution and relative frequency show the ways in which the appearance of /ɨ/ is highly predictable. In support of /ɨ/ as a phoneme, I have identified several lexical and morphological categories that make use of this vowel (and contributed additional minimal pairs with /ʌ/): onomatopoeias, letters of the alphabet, and personal pronouns. The aspect these three classes have in common is that in each case /ɨ/ arguably serves as a support vowel, suggesting it might fill a 'default' or epenthetic role in the language. This is corroborated by native speaker intuitions that the preferable repair for adapting non-native consonant clusters is epenthesis of /ɨ/; additionally, /ɨ/ is reported to be a pause-filling vowel in Romanian, while many other languages use a lower central vowel for that purpose. The extent to which /ɨ/ is actively epenthetic has yet to be explored.

I have tested the strength of /ɨ/'s phonemic independence using both acoustic and perceptual experiments, which have focused on the differences between /ɨ/ and /ʌ/. Results indicate that the two are distinct, although there is some perceptual support of their phonological marginal contrastiveness. Regarding the stability of the contrast between /ɨ/ and /ʌ/: By one characterization, a marginally contrastive relationship is one that, over time, could be subject to neutralization, not necessarily across the

lexicon but just in those places where the functional load of their contrast is small (Sohn 2008). By incorporating acoustic and perceptual experiments into studies of marginally contrastive relationships, we can evaluate the potential of two segments to undergo this type of neutralization. While the present experiments do not offer a complete answer (particularly from the perceptual point of view), the acoustic results indicate separate vowel spaces for /ɨ/ and /ʌ/, suggesting that their contrastiveness is supported not only by of minimal pairs, but also by clear phonetic differences.

6.3.2. A model of phonemic robustness

As discussed in Chapter 3, a model of phonological contrast that permits only a small set of possible contrastive relationships between sounds, or within a phonological system, fails to capture the range of possible relationships between pairs of phones. The investigation of marginal contrastiveness in Romanian highlights the variety of influences on phonemic status and contrastiveness, and thus a desirable model is one that can take into account multiple factors. While other work has brought to light the inadequacy of modeling phonemic status as a sharp distinction between allophones and phonemes (Goldsmith 1995; Hall 2009), the characterization of contrastiveness as a linear continuum is also inadequate. Goldsmith (1995) emphasizes the relevance of lexical contrasts, while Hall (2009) incorporates the role of type frequency in shaping not only contrast among pairs of phones but also that of a single phone within the system.

I have shown that determining the phonemic contrastiveness of a phone is not a simple weighing of functional load and frequency effects. Minimally, Romanian requires the additional dimension of morphologized uses to make sense of vowels' roles in the system. The evidence I have presented highlights the complex set of interacting factors that influence the overall distribution, predictability, and

259

perceptibility of a phone. Multiple dimensions are at work to influence the overall role of a phone in this phonological system, and some have conflicting effects. I have argued on the one hand that Romanian /ɨ/ is highly predictable and therefore less contrastive in some contexts, while also presenting clear evidence of its status as a phoneme. How can we combine these characteristics into a single model, and in fact, what do we want to model about the status of /ɨ/?

By attempting to quantify phones in terms of *contrastiveness*, scholars imply that all segments in an inventory can be ranked with respect to one another. This may be a worthy enterprise, but at some level it is necessarily a pairwise comparison, dependent in previous models (Goldsmith 1995; Hall 2009) on the two dimensions of lexical contrast (or functional load) and contextually-dependent relative frequency. It is not clear what a pairwise comparison tells us about the overall shape of an entire inventory, the robustness of the phonemes within it, and their role within the phonological system.

I propose that instead of continuing to model contrastiveness, we instead consider the multidimensional property of *phonemic robustness*, as a holistic measure of the degree to which a given phone is independent from other forces at work in the linguistic system. A phone that is highly independent, and phonemically robust, is one that combines freely with other phones in the inventory and is not phonologically conditioned; it participates in lexical contrasts, and is not overwhelmingly predictable based on factors such as morphological context. In Romanian, these include the most frequent vowels /i, e, a/, and to a lesser extent /o, u/. A less-robust phoneme, by contrast, is one with a considerable degree of conditioning: phonological restrictions, few lexical contrasts, a distribution characterized by heavy use in certain morphological contexts. In Romanian, these are the marginally-contrastive phonemes /ɨ, e̯a, o̯a/.

The factors relevant for determining the phonemic robustness of a phone are

incorporated into a new multidimensional model, shown in Figure 6.1. These factors

fall into three categories, and overlap with the factors of importance identified in the

models of Hall (2009) and Goldsmith (1995). This model also illustrates whether each

factor correlates in a positive or negative way with phonemic robustness. If an

increase in the strength of a certain factor is predicted to increase phonemic

robustness, then they are positively correlated; but if that factor *reduces* phonemic

robustness, then they are negatively correlated. Correlation is identified in the model

with (+) and (−) signs.
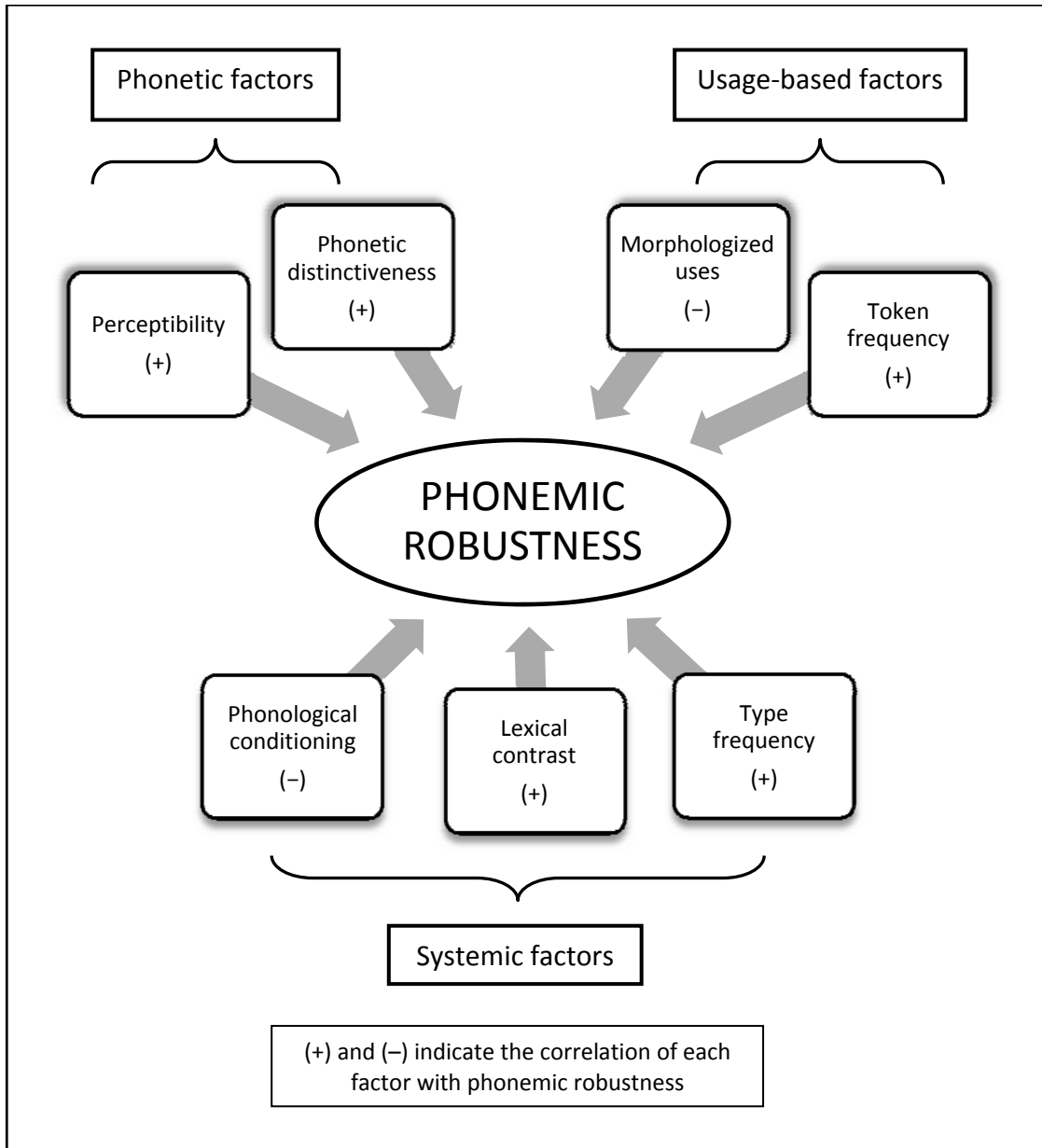
Figure 6.1.   **The Multidimensional Model of Phonemic Robustness**

The first group of factors, shown at the bottom of the model, includes what I term *systemic effects*: lexical contrast, type frequency, and phonological conditioning. These factors are determined by the grammar, or systemic properties, of a particular language. Lexical contrasts are the minimal pairs in which a phone participates;

alternatively, this dimension could be described in terms of functional load, which quantifies the number of lexical distinctions that would be lost if two segments were no longer separate phonemes (Hockett 1966). This factor correlates positively with phonemic robustness: the more minimal pairs exist for a given phone, and the higher the functional load of its contrasts, the more robust its phonemic status.

The second factor in this category is type frequency, which is a measure of how often a phone appears in the lexical roots of a language. Type frequency correlates positively with phonemic robustness: the higher the relative frequency of a given phone, the less predictable we expect it to be, and the more opportunities it has to contrast and combine with other phones in a wide range of contexts. The third factor in this category, phonological conditioning, correlates negatively with phonemic robustness. The more highly a phone is conditioned by the phonology, the more predictable it becomes – and therefore the number of contexts in which it can appear in opposition decreases. Additionally, if the appearance of one phone depends on the presence of another, its independence within the system is diminished.

The second pair of factors, shown at the top right of the model, are *usage-based factors*: morphologized uses and token frequency. Unlike the systemic factors, which are based on a language's phonological and grammatical properties, the magnitude of effect of usage-based factors depends on individual speakers' exposure to the language. Token frequency is a measure of how often speakers use a given form – in this case, a phoneme type – without specific regard for its frequency of occurrence across the lexicon. Morphologized uses, that is the incorporation of a phoneme in a particular morphological marker, are similarly context-dependent. Their effect on phonemic robustness depends on the factors that determine morphological marking, such as syntactic and semantic context. Token frequency, like type frequency, is expected to correlate positively with phonemic robustness.

263

Morphologized use, however, increases the predictability of a phone by placing it in specific contexts, such as in word-final position as we saw for Romanian /ʌ/ and /e̯a/. Thus its correlation with phonemic robustness is negative.

The third category, shown at the top left of the model, are *phonetic factors* which come into play in spoken language, and these are positively correlated with phonemic robustness. Phonetic distinctiveness is a broad category referring to both acoustic and articulatory factors that can affect the phonetic realization of a phone; for example, the degree to which a phone overlaps with others in the acoustic space, or its susceptibility to coarticulation. Perceptibility refers to the perceptual identifiability of a phone, and is the listener-based counterpart to phonetic distinctiveness.

In this dissertation I demonstrate how all of these types of factors are relevant for capturing an aspect of the contrasts within the Romanian vowel system, and I focus on cases of marginal contrast. However, this model shows how the factors investigated here can be applied to an entire phonemic system, to evaluate the independence of its members. While this model includes the factors I believe relevant for determining phonemic robustness, it is only a schematic. It does not take into account the myriad of interactions that occur between types of effects (e.g., between morphologized uses and relative frequency, as shown in §3.5). As remarked in Chapter 3, a fuller understanding of the related effects of type vs. token frequency is also needed. There may be other effects that are not relevant for phonemic robustness in Romanian, but which should be incorporated into subsequent versions of this model.

Just as crucially, the model does not establish the relative importance of each effect in determining phonemic robustness. To posit a more hierarchical and quantitative model, it is necessary to undertake experimental work teasing apart these interacting factors, focusing on one at a time to ascertain their relative importance for

a given phonological system. In the next subsection I propose perceptual experiments to test this model, as well as previously-proposed models of contrastiveness.

6.3.3. Marginal contrastiveness and perception

This dissertation investigates the nature of the relationship between /ɨ/ and /ʌ/ in Romanian from four angles: historical, phonological, acoustic, and perceptual. By combining the results of these studies, we can zero in on how these two sounds interact within the language, and on their consequences for communication. However, the perceptual portion of this endeavor is much less developed than the other two: in Chapter 4 and Appendix C I have presented the results of two simple perception experiments testing whether the contrast between the central vowels is more difficult to perceive than that between front vowels in Romanian.

An expansion of this study will evaluate the perceptual relationship between phonological environment and vowel quality by asking: In Romanian, to what extent does listeners' identification of a central vowel depend on its phonological context? If listeners hear /ʌ/ in the ideal phonological context for /ɨ/, for example, are they more likely to misidentify it than if it fell in the expected context for a mid central vowel? Based on the respective distributions of /ɨ/ and /ʌ/, for example with respect to nasal consonants, we would expect listeners to make strong generalizations over the lexicon regarding the likelihood for each vowel to appear in that context; statistically-based knowledge of this type has been shown to be relevant in speech perception, for example in identifying consonant clusters in English (Pierrehumbert 2003b; Hay, Pierrehumbert & Beckman 2003).

The proposed experiment will place /ʌ/ in stressed, pre-nasal position, comparing its identification rates to /ɨ/ in the same position; conversely, /ɨ/ will appear in an unstressed, preferably post-tonic syllable, and its identification rate will be

compared to that of /ʌ/ in the same context. This type of test was attempted in the first perceptual pilot experiment (see Appendix C), but methodological shortcomings precluded fully interpretable results. This experiment could use nonce words; it is possible that suitable lexical items exist, but if so they are very rare and infrequent in Romanian. Another possible methodology is a cross-splicing experiment, but it is likely that the vowel of interest would carry coarticulatory cues to its consonantal frame (particularly in stressed pre-nasal position), making it difficult to judge what cues listeners respond to. A mismatch of coarticulatory cues in the vowel with the consonantal environment could increase confusion.

Such a study in Romanian would benefit from improved corpora, since the one used here (Chapter 3) approximates type frequency and does not show token frequency. Type frequency is argued to correlate strongly with speakers' statistical knowledge of phonological content within the lexicon (Pierrehumbert 2003b); a corpus of monomorphemic roots gives the clearest picture of this measure. A token frequency corpus would permit quantification of how frequently each phoneme occurs across a sample of written or spoken language, taking into account, for example, the fact that some morphological forms or lexical forms are used with greater frequency than others. This would yield a measurable method to determine how frequently Romanian speakers use each phoneme in communication.

Perception experiments that take phonological context into account could help us test Romanian with respect to Hall's (2009) Probabilistic Phonological Relationship Model. That model allows for an entirely continuous modeling of the degree to which two segments are contrastive, based on entropy (the uncertainty of a choice) and calculations of the segments' likelihood of co-occurrence in a language. This is based on the observation that native speakers are aware of statistical distributions in

language, and use them in speech processing (Saffran, Aslin & Newport 1996; Ernestus 2006).

In particular, a modeling approach combining entropy and contextual relative frequency could test the relationship between the conditional entropy (the uncertainty of a choice, allowing for different levels of uncertainty across specific contexts) of a given pair of sounds, and the environment in which they occur. We would predict low rates of confusion between sounds in a high-entropy (highly contrastive) pair in any environment, and also for a low-entropy (allophonic) pair in the typical environment of each member of that pair. However, we would predict higher confusion for pairs of intermediate contrastiveness, for example with a medium-entropy (partially-contrastive) pair in an environment where both members can occur.

Hall (2009) includes a study of this type, using German nonce words as stimuli. Her results are based on similarity judgments, representing a methodological difference from the pilot studies reported here. Additionally, her study is designed to test distributional facts about sounds' occurrence in German without the goal of illuminating the role of phonological restrictions in perception. In other words, her stimuli are not constructed to place marginally-contrastive pairs in environments that are relevant for the nature of the contrast; nor does she use robustly-contrastive sounds as a control comparison, as I have here. Hall acquires a null result, finding no significant relationship between entropy and perceived similarity between sounds. It is possible that a study targeted at specific phonological environments likely to be loci of confusability, as proposed for Romanian, could find a significant context-sensitive correlation between entropy and confusability or perceived similarity. While it seems unlikely that speakers are aware of extremely fine-grained differences in contrastiveness, it is important to understand the limits of the human perceptual system and their interaction with phonological properties.

267

An alternative model for contrastiveness comes from the Gradient Phonemicity Hypothesis (Ferragne et al. 2011), which computes the 'degree of membership' of a particular phone within the fuzzy set (Scobbie & Stuart-Smith 2008) of phonemic contrasts. These calculations are based on perceptual results from speakers of languages whose inventories differ in crucial ways, and whose stimuli identifications correlate with the system of contrasts in their language. An analogous perception experiment for Romanian and Italian could test whether speakers of Italian, which lacks /ɨ/ and /ʌ/, are able to distinguish the two vowels as well as native Romanian speakers. If Italian speakers perform worse at vowel identification, this would indicate not only that Romanian speakers can tell the difference between them as separate phonemes, but also that they have greater success than speakers of a language without those phonemes. This experiment would fit with research on the relevance of language background for vowel perception (Bennett et al. 1992; Flege, Munro & Fox 1995; Stevens et al. 1969; Terbeek 1977).

6.4.   Morphology: A significant factor

In Romanian, morphological alternations not only have a determining role in the phonology, but they also anchor the phonetics. We see the import of morphology for the phonological system in the distributions of /e̯a/ and /o̯a/, which are shown in Chapter 3 to be almost entirely captured by a finite set of morphological markers. For example, /e̯a/ is a characteristic marker of imperfect verbs, verbs that use the stem extender <ez> (e.g., *fumează* 'smokes (3 sg.)'), and many feminine adjectives; /o̯a/ appears as a feminine suffix *–oare* and in many borrowings, particularly from French adjectives containing [wa]. Additionally, while the phonological processes that brought /ɨ/ into Romanian are no longer active, the place where /ɨ/ is actively inserted

268

into new words is morphologically governed; the vowel appears in onomatopoeias and some verbal gerunds.

The relationship between morphology and phonetics is seen in Chapter 5, in the presence of enhanced coarticulation in contexts that parallel phonological alternations. These alternations are describable in purely phonological terms: metaphony is the conditioning of stressed vowel height by the quality of a following unstressed vowel, and the Labial Effect is centralization of a front vowel following a labial consonant (without another subsequent front vowel). However, the place where these alternations are at work in Romanian is determined by the morphology: both metaphonic and labial-governed alternations typically occur in certain morphological contexts, such as singular vs. plural forms of nouns and adjectives, or between members of a verb paradigm (e.g. the second singular vs. third singular, which often have, respectively, /i/ and /ʌ/ word-finally; compare [fumez^j] 'smoke (2 sg.)' with [fume̯azʌ] 'smoke (3 sg.)').

Thus the increased coarticulation in environments of this type indicates not only parallels to the phonology, but also the displacement (or enhancement) of cues to the morphology. This is seen most clearly in the pilot study result (§5.1.2) that significant anticipatory coarticulation occurs both when a stressed vowel precedes a fully-realized [i], and when the following environment contains /i/ only underlyingly (compare /feti/ [fets^j] 'fetus (pl.)' with /fetii/ [fetsi] 'fetus (pl. def.)'). In the first case, the morphological cue to the noun's plurality – the desinence marker – is highly reduced and displaced leftwards, realized as palatalization of the final /i/ and, I argue, increased anticipatory coarticulation on the preceding /e/. In Romanian there is more anticipatory than carryover vowel-vowel coarticulation: there are significant differences in the formant values of stressed vowels, depending whether the following unstressed vowel is [a] or [i] (Chapter 5). This is precisely the type of environment

269

that would signal, for example, a singular vs. plural form, or a second-person vs. third-person verb.

Thus coarticulation provides a potential cue for morphological form; or conversely, the strength of acoustic cues increases at precisely the location in a word where listeners will attend most to morphological content. To summarize, the powerful links between phonology and morphology in Romanian (laid out in terms of Optimality Theory by Chiţoran 2002c) have a role in influencing the phonemic status of certain vowels and are also manifest in the phonetics.

6.5.   Approaching the phonetics-phonology interface

This dissertation contains several sets of acoustic data, which most straightforwardly reflect on the phonetics of the languages studied herein. These experimental results also highlight the nature of the interface between phonetics and phonology in several ways.

One major finding of this dissertation is the highly context-specific set of results comparing rates of coarticulation in Romanian and Italian (Chapter 5). While previous studies typically have focused on a single direction and type (i.e. vowel-vowel or consonant-vowel) of coarticulation, this study's tightly-controlled nonce word stimuli allow statistical modeling of the relative effects of both carryover and anticipatory vowel-vowel and consonant-vowel coarticulation in Romanian and Italian. Since these languages are genetically related and have many phonological similarities, we infer that any differences in coarticulatory rates are likely due to readily identifiable differences in phonological processes and vowel inventory shape.

We find larger magnitudes of coarticulatory effect overall in Romanian than in Italian, but in both languages the size of effect varies based on the target vowel, indicating that coarticulation does not uniformly apply across a vowel system. In

Italian, carryover consonant-vowel and vowel-vowel effects are larger than anticipatory effects, but are still much smaller than their Romanian equivalents. In Romanian, carryover consonant-vowel coarticulation greatly outstrips anticipatory consonant-vowel coarticulation, which parallels the vowel centralization seen in the Labial Effect; and anticipatory vowel-vowel coarticulation has larger effects than carryover vowel-vowel coarticulation, which shadows the right-to-left directionality of metaphony. Thus effects in Romanian are exaggerated precisely where the phonology and morphology govern alternations, while Italian lacks these processes and also shows only limited coarticulation.

In sum, this comparative coarticulation study reveals phonetic parallels to phonological processes, and the details of the study demonstrate how models of acoustic vowel space can be enriched with the addition of phonologically-informed parameters. These findings permit investigation of the nature of the interface between phonetics and phonology. The acoustic experiment in Chapter 4 and the perception experiments (Appendix C) additionally help to capture in phonetic and perceptual terms the relationships among the vocalic phonemes of Romanian. These experiments begin to test whether the gradient phonological distinctiveness among these phonemes is reflected in their acoustic and perceptual realizations. Future experiments will focus on two important aspects of this work: the perceptibility of coarticulation across languages, and also testing the full extent to which the magnitude of a coarticulatory effect is specific to the qualities of segments involved.

6.5.1. Testing the effects of coarticulation

Chapter 5 includes the finding that rates of coarticulation differ across target vowel qualities, languages, and direction of coarticulation (anticipatory vs. carryover). One question arising from my dissertation work regards the effects of coarticulation,

particularly from unstressed vowels onto stressed vowels, on the perception of vowel quality. The presence of considerable anticipatory coarticulation from unstressed, word-final vowels in Romanian onto preceding stressed vowels parallels morpho-phonological vowel alternations in the language. But is this coarticulation perceived and used by Romanian listeners, to assist decoding of vowel quality or to speed up word identification? A cross-linguistic experiment will shed light on whether differences in perceptual adaptation are a function of the presence of phonological metaphony in a language, which in turn informs our knowledge of the types of processes that can lead to phonological alternation.

As mentioned in Chapter 5, perceptual cross-splicing experiments (Nguyen, Fagyal & Cole 2004) have indicated that listeners use coarticulatory information in word identification tasks. In those experiments, French lexical items both with and without detectable phonetic metaphony (in which the initial unstressed vowel coarticulated with the following stressed vowel) were cross-spliced, and listeners' reaction times were measured in a vowel-identification task. The study found some evidence that listeners responded more quickly when coarticulatory cues to the second vowel's quality were available.

A study of this type is ideal and straightforward for determining whether listeners make use of coarticulatory information in Romanian. Since coarticulatory effects in Romanian exceed the just-noticeable difference threshold (Flanagan 1955), it is likely that in a cross-splicing experiment listeners would be able to detect differences across coarticulatory contexts. However, what are the predictions for a language lacking this phonological effect, such as Italian? Given the relevance of linguistic background for certain types of identification tasks, it is possible that Romanian speakers' phonological and phonetic use of anticipatory vowel-vowel

272

coarticulation (or carryover consonant-vowel coarticulation) would be advantageous in a study of this type, with respect to the abilities of Italian speakers.

A second experiment, acoustic rather than perceptual, will investigate the specificity of the results in Chapter 5. It is possible that the amount of coarticulation depends not only on the quality of the target segment, but also the segment with which it is coarticulating. We might predict different rates of coarticulation depending on the consonantal and vocalic frames. This acoustic experimentation would help flesh out the different articulatory links between segments in a language and test the relative coarticulatory strengths of segments that do and do not participate in phonological alternations with one another. These results in turn would help predict areas of increased phonetic variation in vowel systems across the world's languages.

6.6. Modeling the relationship between phonetics and phonology

The questions explored experimentally in this dissertation can be described most succinctly as investigations of the interface between phonetics and phonology. The acoustic experiment in Chapter 4 and the perception experiments help to capture in phonetic terms the relationship among the vocalic phonemes of Romanian, focusing on /ɨ/ and /ʌ/, which are demonstrated in Chapter 2 and Chapter 3 to be phonologically distinct in a gradient sense rather than a strictly allophonic or contrastive one. In Chapter 5, a comparison between Romanian and Italian reveals phonetic parallels to phonological processes, and the details of that study demonstrate how our models of acoustic vowel space can be enriched with the addition of phonologically-informed parameters. Given the extent to which this dissertation plumbs the depths of the interaction between phonology and phonetics, it is appropriate here to reflect on recent characterizations of their relationship.

Phonetics and phonology represent different aspects of the human language faculty, but neither captures both the abstract cognitive representations of sounds, and how speech manifests physically. While phonetics describes events in the physical world and is best captured by calculus, phonology is a cognitive abstraction whose elements are manipulated by syntactic rules (Pierrehumbert 1990). Both phonetics and phonology are necessary to model human speech communication; however, the question arises of how to mesh the two together, since they are respectively quantitative and qualitative representations.

Trubetzkoy acknowledged the importance of both phonetics and phonology, but argued for a division between phonetics, as the purely scientific study of speech sounds regardless of meaning, and phonology to understand "that aspect of sound which fulfills a specific function in the system of language" (1939:11) and is of psychological relevance. A desire to understand the cognitive and functional link between these two fields has led scholars increasingly to refute a sharp distinction and allow minimally for interaction between phonetics and phonology, or for their placement at opposite ends of a continuum.

One approach to this issue has been to acknowledge the separate natures of these two types of processes, namely that the phonology is discrete and categorical while the phonetics is gradient and continuous, in order to step back and reflect on how phonetics and phonology overlap and share certain characteristics. These have been described in terms of evidence for *phonetics in phonology* vs. *phonology in phonetics* (Cohn 2007; Chiţoran & Cohn 2009); in Romanian we find evidence for the former.

The concept of *phonetics in phonology* refers to the fact that we find *naturalness* in phonology (Archangeli & Pulleyblank 1994): the roots of many phonological processes have identifiable parallels to gradient phonetic effects.

274

Convincing examples of this type are phonological processes, such as assimilation, rooted in coarticulatory effects (Ohala 1990). Cohn (2007) illustrates this with long-distance nasal assimilation in Sundanese, which affects vowels following a nasal consonant; in addition, however, vowels that immediately precede a nasal consonant display a certain amount of nasalization in anticipation of the upcoming consonantal gesture. This is precisely the type of phonetic process hypothesized to result in grammaticalized phonological effects, although the phonological conditioning and phonetic effect are considered parallel and separate.

We find this type of phonetics in phonology in Romanian as well: in addition to metaphony, which is right-to-left vowel height assimilation, we find substantial anticipatory vowel-to-vowel coarticulation. In parallel with the Labial Effect, which is hypothesized to have been historically triggered by the interaction between the second formants of the labial and following front vowel, we find significant carryover consonant-vowel coarticulation. While I do not claim that the synchronic phonetic effect results directly from the phonological alternation at work, the degree to which Romanian phonetics parallels phonology is striking. A greater amount of coarticulation occurs in the environments which are affected by the phonology, such that vowel-vowel coarticulation is greater in the anticipatory direction and consonant effects are greater from left to right. These Romanian results also show that the synchronic phonetic effects do not apply uniformly, or to the same set of contexts where the phonological rule is active; some vowels coarticulate more than others. This supports the argument that while the phonological process is a natural one with phonetic parallels, the two remain distinct.

Increasingly, treatises on the phonetics-phonology interface pull away from distinguishing the two, recognizing the presence of categorical and gradient variables of both phonological and phonetic flavor. Ladd (2006) argues that traditional

275

phonological transcriptions serve as symbolic abstractions of infinitely unique realizations of sounds. This type of model stands in opposition to, for example, the use of the gesture as a quantitative abstraction in Articulatory Phonology (Browman & Goldstein 1986; Browman & Goldstein 1989; Browman & Goldstein 1992; Browman & Goldstein 1995). The contrast between these two models can be characterized as one between discrete and continuous mathematical models. On this basis, Ladd proposes a useful analogy of the phonetics-phonology interface: phonology is equivalent to a language's spelling system, while the phonetics is a particular individual's handwriting, or the physical realization of the more abstract categorical system.

This analogy is particularly useful for describing coarticulation, which can be captured in 'handwriting' terms as the way letters' physical shapes are affected by their linear connections to the letters around them, especially in cursive writing. This analogy, carried to its full extent, illustrates that there really are important linguistic differences, that is less-than-phonemic differences in realization, that are *meaningful* but that cannot be captured by the representation: while two writers' handwriting may have visible differences that provide clues to their identity, we wouldn't say that their spelling (abstract representation) is different. In the experimental results from Chapter 5, we see that although Romanian and Italian speakers produced nonce words whose abstract forms are in some cases phonologically identical (e.g., forms like /kipapi/ or /kapupi/, which were recorded in both languages), their physical realizations are strikingly different. In many ways, these differences are systematic, and in fact they parallel the phonologies of the two languages; this suggests that phonology informs phonetics, and vice versa.

Ladd concludes that a strictly categorical approach cannot work; a gradient model is the only remaining option. However, he does not discard the idea that

phonology and phonetics both exist; he proposes using a "classical phonemic" mapping between the two, where the path from the phonemic level to the physical realization passes straight through rules for phonetic output, without instead going through a systematic phonetic level. This systematic phonetic level is the one that laboratory phonology has shown to be largely gradient,[41] and thus unrealizable in the categorical way implied by SPE-style phonological theory (Chomsky & Halle 1968). The phonemes used in this mapping, however, should not be considered uniform from one language to the next: Ladd proposes the adoption of phonemes as language-specific phonetic categories, or distinctive phones. Simply put, two phones are distinctive in a language if they sound different to a native speaker.

By this definition, the difference between /ɨ/ and /ʌ/ in Romanian is one of distinctive phones, which in most instances (according to pilot perceptual data) are recognizable as separate sounds at rates well above chance. This representation seems to meld the phonetic and the phonological into one continuous category that is sensitive to native speakers' use of a contrast. Ladd argues that "problems [like marginal contrastiveness] largely disappear if we see phonemes as phonetic types or categories, and if we assume that the formation of phonetic categories is a consequence of the whole language environment, not merely lexical contrast" (2006:14). This echoes the approach taken in this dissertation, which takes into account not only the presence of minimal pairs, but also segments' morpho-phonological roles and their acoustic and perceptual realizations to evaluate contrastiveness.

As proposed by Pierrehumbert (2003b), distributional facts are the primary source for the development of distinctive phone categories; applied to the case of

---

[41] From the opposite direction, studies based in phonetics have found categorical effects that undermine the traditional view of phonetic implementations as the realm of variability and gradience (Cohn 2006).

marginal contrastiveness in Romanian, this implies that we should expect to find effects of the distributional restrictions on /ɨ/ and /ʌ/ (and perhaps also /e̯a/ and /o̯a/) in their realization and perception. These distributional effects have resulted in the nearly-complementary relationship between the central vowels, and are tentatively given responsibility for the perceptual result that listeners identify /ʌ/ with lower accuracy than other vowels.

The central findings of this dissertation add to the body of evidence that abstract phonological representations and their physical, phonetic correspondents cannot be described as respectively discrete and continuous sets of factors, nor can they be characterized as autonomous modules. To understand the system of contrasts within a language, we must consider multiple systems. Phonology, phonetics, morphology and perception interact in a multidimensional way, and by comparing their effects we can incorporate each into our models of sound structure.

APPENDICES

APPENDIX A   Romanian /ɨ/, from Slavic words with jer-liquid metathesis

Romanian	*Common Slavic	Old Church Slavonic (attested) form	
bârlog	bVr	brŭlogŭ	'lair' (of animal)
bârna	brV	brŭvĭno	'wooden beam'
câlţi	klъk-ъ or kъlk-ъ	klŭkŭ	'flax fibers'
cârcă	? *not found*	krŭkŭ	'behind, shoulders'
cârci	? *not found*	krŭčiti	'squeeze'
cârmă	kъrma	krŭma	'helm'
cârn	kъrn-ъ	krŭnŭ	'snub(nosed)'
cârpă	kъrpa	krŭpa	'cloth, rag'
cârpaci	? *not found*	kurpačĭ	'bungler'
cârpi	kъrpa	krŭpiti	'patch' (vb)
cârstă	? *not found*	krŭstŭ	'cross of grain'
covârşi	-vьrši-ti	povrŭşiti	'conquer'
dârjala	dьržati-lo	družalo	'handle, walking-stick'
dârz	dьrz-	druzu	'courageous'
drâglu	drьg-lo	drŭgati + lo	'wool carder'
gâlceavă	gъlk-ъ	glŭkŭ	'fight, quarrel'
gâlmă	xъlm-ъ	chlŭmŭ	'small hill, swelling'
gârbă	gъrb	gŭrbŭ	'back, ridge'
gârbov	gъrb-av-ъ	grŭbavŭ	'bent'
gârlan	gъrl-o	grŭlo	'vagabond'
hârtop	vьrtъrъ	vrŭtŭpŭ	'pothole'
învârti	vъr…	vrŭtěti	'spin'
mâlc	mъlk-	mlŭkŭ	'psst! shh!'
mârşav	mьrš-	mrŭšavŭ	'weak, lazy'
năpârstoc	na-pьrst-ъ	naprŭstŭkŭ	'ring'
nesfârşit	ne-sъ-vьrš-i-ti	sŭvrŭšiti	'endless'
obârşie	ob-vьrš-	obrŭsĭ	'origin, hometown'
ocârmui	o-kъrm-i-ti	okrŭmiti	'govern'
osârdie	o-sьrd-ьce	osrŭdije	'concern, care'

ovârşi	o/u-vьrš-i-ti	uvrŭşiti	'execute'
pâlc	Germanic origins	plŭkŭ	'regiment'
pâlnie	pъl…	plŭniti	'funnel'
pâls	pъl…	plŭchŭ	'hedgehog, dormouse'
pârdalnic	pro-da-lь-nik-ъ	prodalĭnikŭ	'cursed'
pârgă	? *not found*	prŭga	'ripeness'
pogârci	po-gъr-ki-i-ti	po + grŭciti	'pick, hunt around for'
râjniţă	žьrny	žrŭny	'mill'
sârb	sьrb-in-ъ	srŭbinŭ	'Serb'
săvârşi	sъ-vьrš-i-ti	sŭvrŭšiti	'do, perform, commit'
scârbă	skъrb-ь	skrŭbĭ	'disgust'
scârnă	skvьrna	vrŭchŭ	'excrement'
sfârşi	sъ-vьrš-i-ti	sŭvrŭšiti	'conclude'
sfârşit	sъ-vьrš-i-ti	sŭvrŭšiti	'end'
sgârci	gъr-ki-i-ti	sŭgrŭčiti sę	'be stingy'
smârc	smьrk	smrŭkŭ	'mud, swamp, puddle'
smârd	smьrd-ъ	smrŭdŭ	'nasty'
şovârf	sux-o-vьrx-ъ / vьrch-ъ	suchovrŭchŭ	'kind of plant'
stâlp	stъlp-	stlŭpŭ	'pillar'
stârc	Germanic origins?	strŭkŭ	kind of bird (stork)
stârni	? *not found*	strumiti	'chase, awaken'
stârv	stьrvb	strŭvo	'corpse'
tâlc	tъlk-	tlŭkŭ	'meaning, sense'
ţârcovnic	cьrk-ъv-ьnik-ъ	crŭkovĭnikŭ	'sexton'
târg	tъrg-ъ	trŭgŭ	'market'
târn	tьrnъ	trŭnŭ	'broom'
târş	? *not found*	trŭsĭ	'branch'
târsână	trъst-	trŭstĭnina, trŭsina	'braid of horse or goat hair'
vâlvă	vъlv-	vlŭchva	'sensation, stir'
vâlvătaie	vъlv-	vlŭchva	'blaze'
vârcolac	vьlk-o-dlak	vrŭsta, vrŭstŭ	'werewolf'
vârşe	vьrš	vrŭşije	'fish-trap'
văzdârjanie	vъz-dьržan-ьje	vŭzdrŭžanije	'self-denial'
zârna	zьrno	zrŭno	'grain'

APPENDIX B Romanian onomatopoeic verbs

Romanian onomatopoeia	
bâcâi	'beat'
bâhli	'stink'
bâigui	'mumble'
bâjbâi	'search blindly'
bâlbâi	'stutter'
bâldâbâc	'splash'
bâltâcâi	'fall unexpectedly in water'
bârfi	'chatter'
bârâi	'pester'
bâstâcâi	? *not found*
bâtâi	'beating noise'
bâţâi	'jerk, shiver'
bâzâi	'buzz'
bâzdâcâi	? *not found*
cârâi	'croak'
cârcâi	'make bird noises'
dârâi	'scratch'
dârdâi	'tremble, vibrate, shiver'
fâlfâi	'flutter'
fârnâi	'flutter'
fârţâi	'wander'
fâsâi	'fizz'
fâstâci	'intimidate'[42]
fâşâi	'rustle'
fâţâi	'fidget'
gâfâi	'pant'
gâgâi	'gaggle'
gâjâi	'breathe hard'
gâlgâi	'gurgle'
gângâi	'mutter, stutter'
gârâi	? *not found*
hârâi	'make hoarse sounds, whisper'
hârcâi	'breathe hard'
hârşâi	'grate'

---

[42] *fâstâc*, the root of this word, refers to the sound of fidgeting or movement.

hârşcâi	'scrape, grate'
hârşi	? *not found*
hârşni	'slice'
hâşâi	'hiss (at birds)'
hâtâi	'stagger'
hâţâi	'stagger'
mângâi	'console, encourage'
mârâi	'growl, snarl'
mâşcâi	'stumble'
pâcâi	'puff'
pâlpâi	'flicker'
pârâi	'crack'
pârpâli	'crack'
râcâi	'scratch, pick at'
râgâi	'burp, belch'
rămâi	? *not found*
sâcâi	'wiggle, fidget, wag, harass'
sâsâi	'hiss (as a snake)'
şâşâi	'soothing hiss, as to a small child, to help him fall asleep'
scârţâi	'squeak, crunch, creak'
sfârâi	'sizzle'
sfârcâi	'snort'
smâc	*interjection*
smârcâi	'snort repeatedly'
şontâcâi	'limp, hobble'
târâi	'drag'
ţârâi	'chirp, buzz'
ţârcâi	'squirt'
ţâţâi	'chirp, buzz'
vâjâi	'have a buzzing in one's ears'
vâlvâi	? *not found*
zbârnâi	'rumble (engine), buzz'
zgâlţâi	'jolt, shake'
zgâţâi	'jolt, shake'

APPENDIX C   Perception of vowels in Romanian

A.1.   **Introduction**

When we consider the question of phonological contrast within a language, we find that phones are generally considered to be either contrastive, in which case they are understood to be separate phonemes; or they are understood to be allophones. The case of /ʌ/ and /ɨ/ in Romanian presents a different situation: these two vowels were once allophonic, having historically arisen under phonological conditioning of /a/, but they are now separate phonemes, as evidenced by minimal pairs. However, the minimal pairs that separate these central vowels are very few, and their contrast is tenuous because when we consider the phonological environment in which a particular vowel is found, we can largely predict whether the vowel is likely to be /ʌ/ or /ɨ/: /ʌ/ tends to be found in unstressed syllables, while /ɨ/ often lies in stressed syllables, especially preceding a nasal. I have proposed that /ʌ/ and /ɨ/ are in a relationship of *marginal contrastiveness*.

Considering the question of contrastiveness from a perceptual point of view, I present two pilot experiments designed to investigate whether the marginal contrastiveness of a phoneme is related to listeners' ability to correctly identify it. Additionally, these experiments begin to provide data on vowel perception in Romanian, about which little is known. In the context of these experiments, I hypothesize that when two vowels are contrastive, participants will distinguish between them with a high rate of accuracy, regardless of the segmental context in which they appear. If they are allophonic, however, I predict high rates of confusion between the two vowels, except in environments where one allophone is predicted over the other. In this context, a high rate of confusion need not mean that correct identification rates are at or below chance: participants may be able to physically

283

perceive a difference between two stimuli, but this does not entail that they are perceived as separate phonemes (Whalen, Best & Irwin 1997). Here I compare rates of confusion among four Romanian vowels: the marginally contrastive central vowels /ɨ/ and /ʌ/, and the robustly contrastive front vowels /i/ and /e/. I hypothesize that if the contrastiveness between /ʌ/ and /ɨ/ in particular is weaker than that between any other pair of vowels (i.e. if marginal contrastiveness holds), then the rate of confusion between /ʌ/ and /ɨ/ should be higher than within any other given pair.

A.2.   **Methodology**

The two pilot studies described here differed in the number and content of stimuli, as well as the number of participants, but the same methodology was used to select and prepare the stimuli for each.

A.2.1.   Materials

The experiment described in this chapter used stimuli gathered from 28 Romanian words: seven words containing one of four vowels, /i e ɨ ʌ/. Each word was chosen as part of an informal phonotactic paradigm: the consonantal environments surrounding the stressed vowel of interest matched across vowel types; for example, the set included four words of the form /#mVr/. Four other words, in which the target stressed vowel was preceded by /#p/, were chosen for a pre-test practice session. Each of the words was recorded in the frame sentence *Spune X da trei ori* 'Say X three times.' A single native speaker of Romanian, originally from Botoşani in the northeast of Romania, read the stimuli, three times each. The stimuli were digitally recorded at 44 kHz in the Cornell University Phonetics Laboratory.

From the three recorded repetitions of each word, one recording was selected, on the basis of duration of the target vowel, in the following way: the duration of the

284

target vowel in each of the three recordings was measured, and across words I compared the durations of each of the vowels recorded. I selected, across vowel qualities, the vowels whose durations were most similar. The experiments involve vowels at different heights, and we expect high vowels are expected to have intrinsically shorter durations than mid vowels (Lehiste 1970), a pattern which we have seen holds in Romanian (§4.8). Here, I have compromised on the relative differences in duration that contribute to height-based naturalness in favor of absolute similarity of duration, a choice that could create a confound for listeners. The reasons for this choice are explained below.

A summary of the stimuli appears below in Table A.1, which also shows which stimuli were used for each pilot study. The portion of the word participants heard (described below) is shown in **bold**, including the stressed vowel in each case.

The recordings of words listed in Table A.1, within their frame sentences, were used to create the stimuli for these experiments. To abstract from the lexical content of each word, a selection technique was used similar to that found in gating experiments, although the experimental paradigm differed in significant ways. In a gating paradigm (Lahiri & Marslen-Wilson 1991), participants hear a series of stimuli of progressively longer duration: the first stimulus is the shortest, for example including only a CV transition; the second includes the CV transition and a larger portion of the vowel, from the same word; and subsequent stimuli include still larger portions of the target word. The prediction is that listeners will identify shorter stimuli with less accuracy than longer stimuli, because in the former case they hear less of the target word and have less acoustic information on which to base their choice. In these studies, I created stimuli of varying lengths, but played them in random order rather than in sequence.

Table A.1. **Words used in pilot studies, with duration of stressed (target) vowel**

Experiment	Front Vowels		Vowel Duration (s)	Central Vowels		Vowel Duration (s)
2	e	**de**se	0.135	ʌ	**dʌ**	0.212
2	e	**fe**te	0.112	ʌ	**fʌ**tul	0.112
1, 2	e	**me**re	0.154	ʌ	**mʌ**rul	0.161
practice	e	**pe**te	0.117	ʌ	**pʌ**turi	0.114
2	e	**re**ce	0.133	ʌ	**rʌ**ul	0.104
2	e	**se**te	0.127	ʌ	**sʌ**ruri	0.150
2	e	**tse**se	0.136	ʌ	**tsʌ**rile	0.132
2	e	**ve**sel	0.129	ʌ	**vʌ**rul	0.114
2	i	**di**mʌ	0.119	ɨ	**dɨ**rʌ	0.128
2	i	**fi**nʌ	0.118	ɨ	**fɨ**nul	0.102
1, 2	i	**mi**re	0.158	ɨ	**mi**rɨi	0.137
practice	i	**pi**scul	0.105	ɨ	**pɨ**nʌ	0.113
2	i	**ri**mʌ	0.134	ɨ	**rɨ**ul	0.079
2	i	**si**tʌ	0.105	ɨ	**sɨ**nul	0.108
2	i	**tsi**ne	0.116	ɨ	**tsɨ**rʌ	0.137
2	i	**vi**te	0.105	ɨ	**vɨ**rʌ	0.122
1 (nasal)				ʌ	**ti'gʌ**i	0.117
1 (nasal)				ʌ	**giŋ.'gʌ**ni	0.148
1 (nasal)				ɨ	**gɨ**nd	0.135
1 (nasal				ɨ	**gɨ**t	0.112

Duration was a criterion for recording selection because of the gating design: in a gating experiment, a basic decision is whether each gate has the same number of milliseconds of increase in duration, or whether the increase is proportional. I chose a proportional increase, which can be more easily linked to the "landmarks" of each vowel, such as transitions, which are proportional rather than absolute. Consider that by measuring 40ms into an /a/ we might still be in the transition, but the same duration would reach almost to the end of an /i/. In some gating experiments the stimuli are played with successively longer gates, to test when listeners can correctly identify a segment; and in that case, absolute duration increases are appropriate. Here, however, the stimuli were randomized, making absolute duration less of an issue. Additionally,

by obscuring some durational cues to vowel height, the experimental design encouraged participants to depend on formant values to perform the identification task.

Each selected recording was used to make four separate sound files, as shown graphically in Figure A.1. This figure shows where each of the four gates, also listed below, were aligned within the target vowel.

a. The "TRANS" gate ends at the conclusion of the transition into the vowel; that is, at the point where F1 and F2 reach a steady state.

b. The "1/3" gate includes the first third of the vowel. This portion was always longer than the TRANS gate, but was nearly always shorter than a just-noticeable difference (Klatt 1976), with the result that we may not expect listeners to perform differently on the TRANS and "1/3" gates.

c. The "2/3" gate includes the first two thirds of the vowel.

d. The "FULL" gate includes the entire vowel, including the transition towards any following consonant. As a result of the durationally-based stimulus selection process, some of these tokens (especially /ʌ/ and /e/) are probably shorter than listeners would expect, while others (/i/ and /ɨ/) are likely longer than in natural speech.
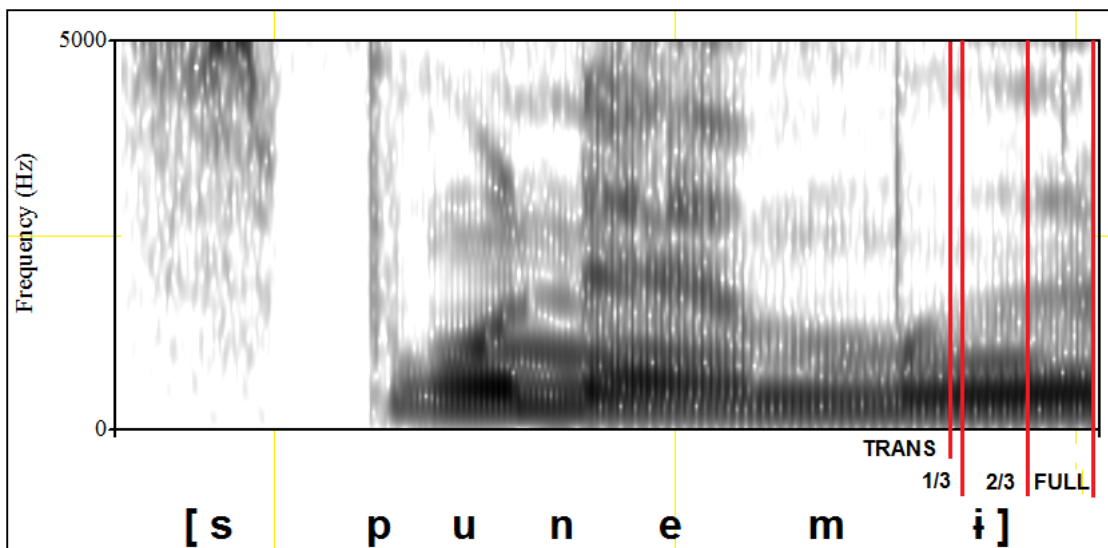
Figure A.1. **Example segmentation of stimuli for ['mɨ.rɨj].**
Participants heard the sound file represented by this
spectrogram.

A.2.2. Procedures

The experiments were run on a laptop computer using E-Prime 2.0 software
running the Windows 7 operating system, and all text and instructions were presented
in Romanian. During the experiment, participants heard stimuli through a pair of
Sennheiser 156 headphones, with the volume adjusted to a comfortable level. Before
the presentation of each stimulus, a fixation cross was displayed in the center of the
screen for 1000 ms. The next screen contained four letters: i, e, â (/ɨ/) and ă (/ʌ/), and
appeared simultaneously with the audio stimulus (since Romanian orthography is
approximately phonemic, each vowel phoneme corresponds to a different written
character). Upon hearing the stimulus (i.e. the frame sentence through the chosen cut-
off point in the target vowel, as in Figure A.1), participants pressed on the computer
keyboard a key corresponding to the last vowel they had heard,[43] which was always

---

[43] The location of the letters on the screen roughly matched the location of the computer keys used for
identification. The letter "i" appeared in the top left corner of the screen, and in order to select that
sound, speakers had to press the "Q" key (which also appears around the "top left" corner of the

the last sound in the stimulus. They were then prompted to give a confidence rating (1-5, where "5" is "extremely certain"), and at the following screen pressed the space bar to move on to the next stimulus. Thus the experiment was self-paced, although participants were instructed to respond as fast as possible.

The experiment began with a practice session, in which participants first heard each of the 16 practice stimuli (4 words x 4 gates each, randomized) and did not have to choose a vowel, but only looked at the screen, to get used to the way stimuli were presented. The practice stimuli were then presented a second time, and participants selected both vowels and confidence ratings. This gave ample time for participants to ask questions and become comfortable with the experimental setup before beginning the testing phase.

A.3.   **Pilot study #1**

The stimuli of the first pilot study contained two sets of words: first, a 'basic' condition, in which all four vowels were included and the phonological environments surrounding each word matched; in the second, only /ɨ/ and /ʌ/ were tested, and each vowel appeared before either a nasal /n/ or a non-nasal consonant. The second condition was intended to test the sub-hypothesis that accurate identification of /ʌ/ and /ɨ/ depends on the surrounding consonants, in ways that reflect the environments in which each vowel was originally conditioned (see §2.1.2 and §2.2.1). This pilot study presented 32 individual stimuli, with the stimuli from each condition randomized together, in five blocks, for a total of 160 responses per participant.

---

keyboard), which for purposes of the experiment was covered with a label indicating "i", as were all the keys used for response selection. "e" appeared in the bottom left, and corresponded to the "Z" key; "â" appeared in the top right and corresponded to the "O" key; and "ă" appeared in the bottom right and was linked to the "M" key. The keys were additionally selected to be maximally distant from one another on the keyboard, to minimize keystroke mistakes.

The experiment was run in Cluj-Napoca, Romania, with a total of 39 participants. Experimentation took place in a quiet office at the Alpha Center, within the Faculty of Letters at Babeş-Bolyai University in Cluj; or in private homes or hotels. Eight men and 31 women participated; their ages ranged from 21 to 62, with an average age of 32. Most participants were teachers at the Alpha Center, a language teaching and testing center associated with the university; others were students, their friends and family. All participants were native speakers of Romanian and knew at least one foreign language, and some spoke as many as four other languages; most participants conversed in English with the experimenter, although all consent forms were in Romanian. No participants reported hearing or speaking problems.

A.3.1.   Results and discussion

While participants generally found the task quite easy and performed very well at vowel identifications, every listener made at least one misidentification. I first show the results in the basic identification condition, in which all the target vowels appeared in an /#mVr/ frame. The pooled results for all speakers are summarized in Table A.2, which is a confusion matrix (Miller & Nicely 1955), designed to show how often speakers correctly identified vowels, and when they misidentified them, what their incorrect responses were. The symbols on the left (rows) represent the correct response; the symbols at the top (columns) show what listeners' responses were. The percentages in each box correspond to each *correct response*; thus in row 1 of Table A.2, we see that listeners correctly identified /e/ in 99.6% of cases, but misidentified it as /ʌ/ 0.1% of the time and as /ɨ/ in 0.3% of cases. The shading in Table A.2 corresponds to the percentage contained in a given box: the darker the shading in the box, the higher the percentage. In Table A.2 and other results shown here, the darkly-shaded boxes along the diagonal correspond to correct vowel identifications; however,

290

the box at the intersection of /ʌ/ − /ʌ/ is lighter gray, and in fact listeners performed much worse at identifying /ʌ/ than any other vowel.

Table A.2.   **Basic vowel identification condition: Accuracy, pooled by gate, listener, and word**

BASIC	RESPONSE			
Vowel	i	ɨ	ʌ	e
i	98.3%	0.1%	0.0%	1.6%
ɨ	0.9%	98.6%	0.5%	0.0%
ʌ	0.4%	24.3%	75.4%	0.0%
e	0.0%	0.3%	0.1%	99.6%

The accuracy rates for each gate within each word are displayed separately, in Table A.3. There, we see the most striking results: first, that accuracy is very high overall; secondly, that accuracy for identifying /ɨ/ is consistently higher than that for /ʌ/, and in fact, rates for /ɨ/ are comparable with accuracy for /i/ and /e/. Finally, in the results for /mʌrul/, we see gradient differences in accuracy for identifying /ʌ/: in the transition and first-third conditions, accuracy is comparable, at 62% and 65.5%. That these results are very similar makes sense, since the actual duration difference between the two conditions is likely shorter than a just-noticeable difference. When the first two-thirds of the vowel are played, accuracy jumps to 76.5%, and accuracy is comparable to that of the other vowels only when the full vowel is heard.

Table A.3.   **Basic vowel identification condition: Accuracy by gate within each word, pooled by listener**

RESPONSE						RESPONSE			
/mɨrɨj/	/i/	/ɨ/	/ʌ/	/e/	/mʌrul/	/i/	/ɨ/	/ʌ/	/e/
TRANS	1.0%	98.0%	1.0%	0.0%	TRANS	1.0%	33.5%	65.5%	0.0%
1/3	2.5%	96.5%	1.0%	0.0%	1/3	0.0%	38.0%	62.0%	0.0%
2/3	0.0%	100.0%	0.0%	0.0%	2/3	0.5%	23.0%	76.5%	0.0%
FULL	0.0%	100.0%	0.0%	0.0%	FULL	0.0%	2.5%	97.5%	0.0%

/mere/	/i/	/ɨ/	/ʌ/	/e/	/mire/	/i/	/ɨ/	/ʌ/	/e/
TRANS	0.0%	0.0%	0.0%	100.0%	TRANS	100.0%	0.0%	0.0%	0.0%
1/3	0.0%	0.0%	0.5%	99.5%	1/3	100.0%	0.0%	0.0%	0.0%
2/3	0.0%	0.0%	0.0%	100.0%	2/3	100.0%	0.0%	0.0%	0.0%
FULL	0.0%	1.0%	0.0%	99.0%	FULL	93.0%	0.5%	0.0%	6.5%

This table shows that /ʌ/ tends to be misidentified as /ɨ/ more than any other vowel. When listeners hear the first third of the vowel (1/3), they perform slightly better on /ʌ/; but even hearing a larger portion of the vowel (2/3, FULL), their correctness rate is lower than that for /ɨ/. It is unclear why this should be the case, and it is unlikely that type frequency effects triggered by coarticulation are the reason for these misidentifications, given the phonological frame /#mVr/. The rates of co-occurrence for both vowels after /m/ are comparable (4% for /ʌ/, 5% for /ɨ/), while /ʌ/ occurs much more frequently before /r/ than /ɨ/ does (18% for /ʌ/, 8% for /ɨ/; data from Chapter 3). Conversely, /ɨ/ was identified with near-perfect accuracy in the TRANS condition, where it could be perceived either as a lexical vowel, or as the final element of a phonemic or carefully-released pronunciation. This result indicates that a short duration alone does not trigger increased confusion, at least for /ɨ/.

The nasal condition, on the other hand, attempted to test the prediction that since /ɨ/ is found before a nasal approximately 75% of the time (based on type-frequency results), while /ʌ/ is not, listeners should tend to perceive /ɨ/ in pre-nasal position and /ʌ/ in other environments. Table A.4 shows that this prediction does not seem to hold: first, /ɨ/ is correctly identified in /gɨt/ at approximately the same rate as

292

in the basic condition (/mɨrɨj/), while in pre-nasal position, accuracy drops to only 94%, and in 6% of cases it is misidentified as /ʌ/.

Table A.4. **Accuracy within the nasal condition, by gate and word, pooled by subject.**

	RESPONSE			
/gɨnd/	/i/	/ɨ/	/ʌ/	/e/
TRANS	0.0%	95.5%	4.5%	0.0%
1	0.0%	97.5%	2.5%	0.0%
2	0.0%	92.5%	7.5%	0.0%
FULL	0.0%	90.0%	10.0%	0.0%

	RESPONSE			
/gɨngʌni/	/i/	/ɨ/	/ʌ/	/e/
TRANS	0.5%	17.0%	82.5%	0.0%
1	0.0%	13.0%	87.0%	0.0%
2	1.0%	7.0%	92.0%	0.0%
FULL	17.0%	8.0%	75.0%	0.0%

/gɨt/	/i/	/ɨ/	/ʌ/	/e/
TRANS	0.0%	99.0%	1.0%	0.0%
1	0.0%	96.0%	4.0%	0.0%
2	0.0%	99.0%	1.0%	0.0%
FULL	0.0%	99.0%	1.0%	0.0%

/tigʌj/	/i/	/ɨ/	/ʌ/	/e/
TRANS	17.0%	29.0%	54.0%	0.0%
1	14.0%	19.0%	67.0%	0.0%
2	9.0%	2.0%	89.0%	0.0%
FULL	13.0%	2.0%	85.0%	0.0%

The two words containing /ʌ/ present a more complicated case, because the target /ʌ/ is not in the first syllable, like it is in all other words. Many participants reported that when they heard certain stimuli, they tended to "complete the word" in their heads, and tended to mention /tigʌj/ and /gɨngʌni/ as the words for which they did this, additionally reporting that this tendency for lexical completion might have influenced their vowel identification choice. Despite the fact that subjects heard a greater portion of these two words, such that vowel identification might have been based on lexical intuitions, their identifications were not considerably better than in the basic vowel condition of /mʌrul/. In the nasal condition, other confusing factors are at play for stimuli containing /ʌ/: in both of the stimuli, an /i/-like element follows /ʌ/, and this may have triggered considerable anticipatory coarticulation in the stressed /ʌ/. In both /tigʌj/ and /gɨngʌni/, lexical completion effects may have influenced subjects' vowel choice towards /i/. While interesting, these results impede any real interpretation of the data in the nasal condition.

293

The uninterpretability of data from the nasal condition leaves the first pilot experiment with data from only one phonological environment, the /#mVr/ frame. To learn whether the effects seen in that environment carry to other phonological frames, we turn to the second study.

A.4.   **Pilot study #2**

This study expanded the phonological environments in which the four target vowels appeared, as shown above in Table A.1, to include 28 words. These produced 112 individual stimuli, which were played in five randomized blocks for a total of 560 responses per participant. The study took place in the Cornell University Phonetics Laboratory. Five women and two men participated; their ages ranged from 21 to 30 years. All participants were undergraduate or graduate students at Cornell University, and were native speakers of Romanian and knew at least one foreign language; participants conversed in English with the experimenter, although all consent forms were in Romanian. No participants reported hearing or speaking problems. The experimental setup and stimulus selection procedures were identical to that described for the first pilot study.

To further understand the acoustic properties of the stimuli used in this experiment, the formant values of each chosen token were analyzed. F1 and F2 were measured at the one-quarter and one-half points of each stimulus, using the methodology described in §4.2. The values for each of these time points are graphed in Figure A.2 and Figure A.3, below, in which each symbol represents an individual word: there are seven data points per vowel. Comparing the data measured at the one-quarter point to those at the one-half point of the vowels, we see that the measurements taken early in each vowel are clustered more closely together across vowel types than those taken at the vowel midpoint. In other words, at only one-

quarter of the way through vowel production (in the CV transition), the speaker's

realizations of each vowel are not as distinct as at the midpoint (in the steady state).

The areas of greatest overlap are between /e/ and /ʌ/ in F2, and /ʌ/ and /ɨ/ in F1: the

token of /ʌ/ with low F1 is from /rʌul/, and the /ɨ/ token with high F1 is from /sɨnul/.

The atypical acoustic measurements of these two tokens may be due to the consonants

flanking each target vowel: both /r/ and /n/ are segments that can have significant

acoustic effects on vowels, and historically conditioned the split between /ɨ/ and /ʌ/ in

Romanian.
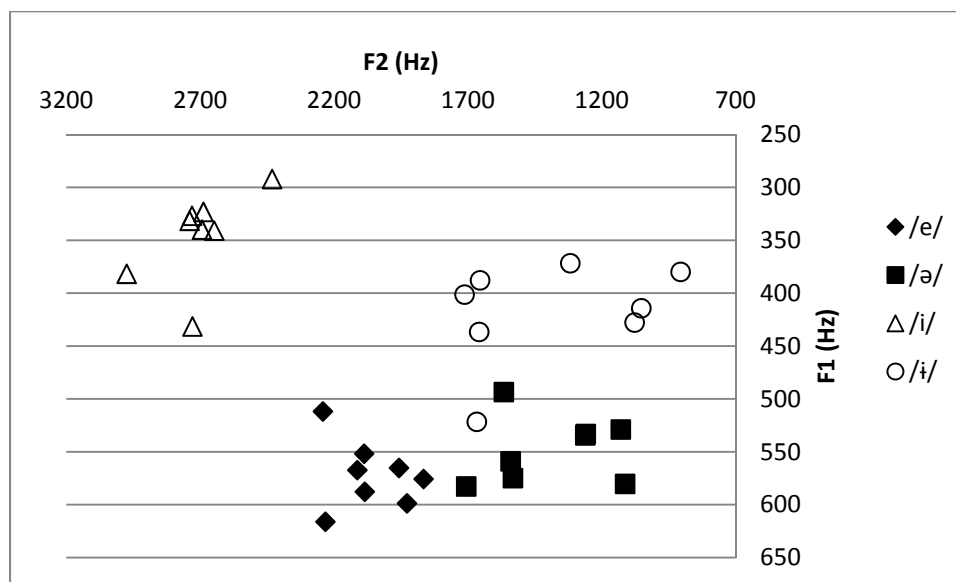
Figure A.2.   **F1-F2 of stimulus vowels at their quarter point**
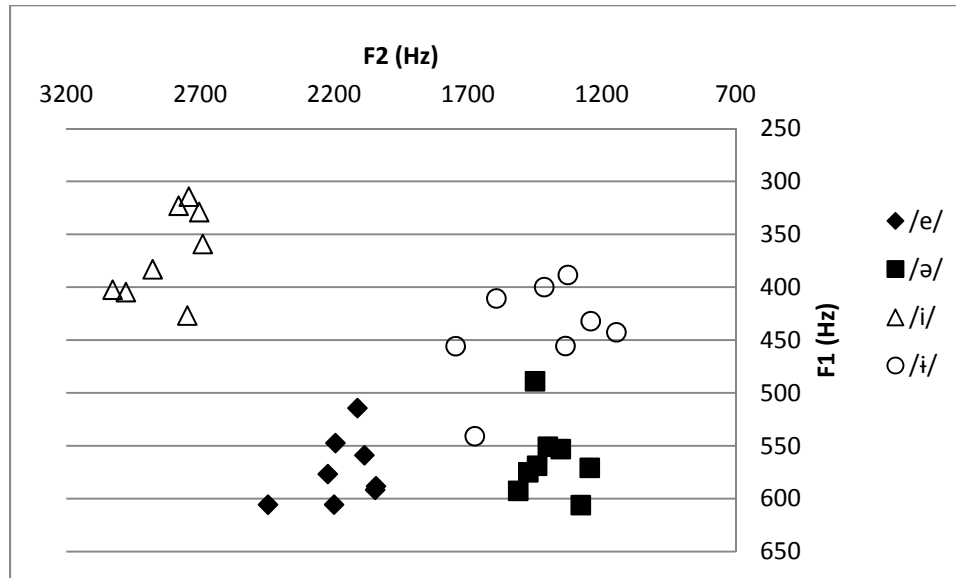
Figure A.3.   **F1-F2 of stimulus vowels at their half point**

A.4.1.   Results and discussion

As in the first study, participants generally found the task easy and made relatively few misidentifications, but each listener made at least one misidentification. I first discuss the results descriptively, and then use a mixed-effects model to statistically quantify the rates of accurate vowel identification and evaluate my experimental hypotheses. This experiment contained stimuli from 28 different words; to save space, I present data tables in which identification rates are pooled across words and phonological environments, but separated by gate length and vowel type, shown in Table A.5.

Table A.5. **Overall accuracy by word; pooled by listener and gate**

/i/	i	ɨ	ʌ	e
/mire/	99.3%	0.0%	0.0%	0.7%
/tsine/	98.6%	1.4%	0.0%	0.0%
/vite/	99.3%	0.0%	0.0%	0.7%
/dimʌ/	100.0%	0.0%	0.0%	0.0%
/finʌ/	100.0%	0.0%	0.0%	0.0%
/rimʌ/	100.0%	0.0%	0.0%	0.0%
/sitʌ/	97.9%	0.0%	0.0%	2.1%

/ɨ/	i	ɨ	ʌ	e
/fɨnul/	0.7%	84.3%	5.0%	10.0%
/mɨrɨi/	0.0%	85.7%	3.6%	10.7%
/rɨul/	0.0%	85.7%	10.7%	3.6%
/sɨnul/	0.0%	97.1%	0.0%	2.9%
/dɨrʌ/	0.0%	85.7%	0.0%	14.3%
/tsɨrʌ/	0.0%	100.0%	0.0%	0.0%
/vɨrʌ/	0.7%	85.7%	6.4%	7.1%

/e/	i	ɨ	ʌ	e
/dese/	0.0%	0.0%	0.7%	99.3%
/fete/	0.7%	0.0%	6.4%	92.9%
/mere/	0.0%	0.0%	5.7%	94.3%
/rece/	0.0%	2.1%	10.0%	87.9%
/sete/	0.0%	10.0%	0.7%	89.3%
/tsese/	0.0%	12.9%	0.7%	86.4%
/vesel/	0.0%	0.0%	5.7%	94.3%

/ʌ/	i	ɨ	ʌ	e
/dʌ/	0.7%	1.4%	86.4%	11.4%
/fʌtul/	0.0%	7.1%	90.7%	2.1%
/mʌrul/	0.0%	18.6%	77.1%	4.3%
/rʌul/	0.0%	8.6%	88.6%	2.9%
/sʌruri/	0.0%	13.6%	85.7%	0.7%
/tsʌrile/	0.0%	13.6%	85.7%	0.7%
/vʌrul/	0.0%	5.0%	92.9%	2.1%

The results shown above generally reiterate the findings of the first pilot study – namely, that /ʌ/ is identified with lower rates of accuracy than the other vowels. Overall, /i/ is identified with near-perfect accuracy, and rates for /e/ are lower, followed by those for /ɨ/ − but there are differences in accuracy across words, which were generally larger than differences across gates (data not shown). The corresponding confidence ratings appear in Figure A.4; they show that while participants were overall highly confident about their responses, there are reductions in confidence in areas where more misidentifications occurred (/ʌ/ in particular). Interestingly, the worst-identified and lowest-rate word out of all was /mʌrul/, which also appeared in the first pilot study, and for which accuracy rates were also lowest. This suggests that some characteristic of this word or subset of stimuli makes it difficult to identify.
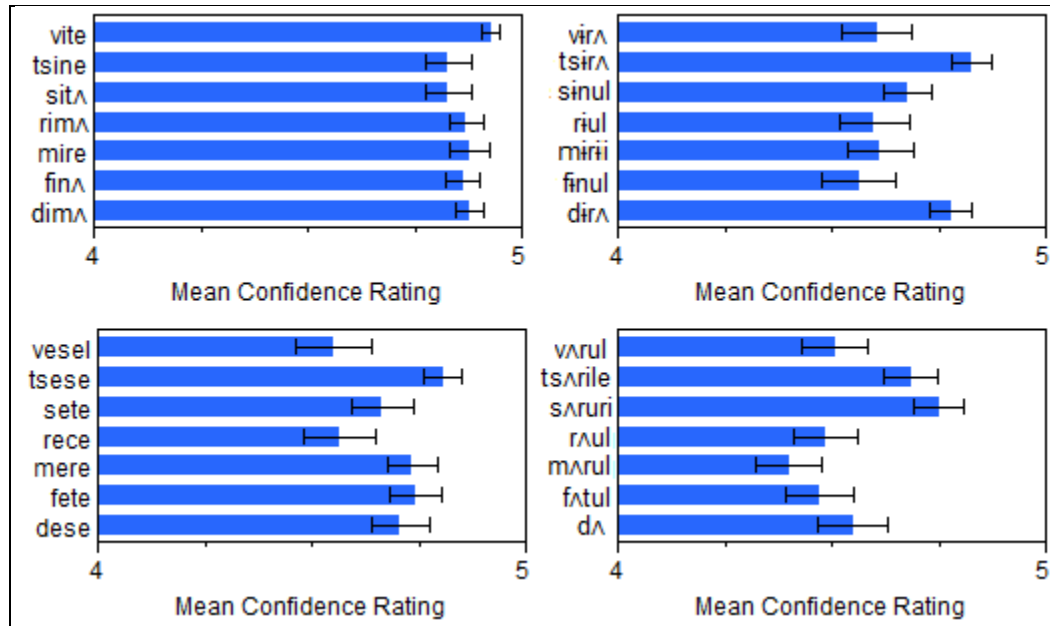
Figure A.4.   **Average confidence ratings, by word**[44]

If /ʌ/ and /ɨ/ are as robustly phonemic and contrastive as other tested vowels,

then the rate of confusion for all vowels included in the experiment should be roughly

the same. Descriptively, in the results above, it appears that this is *not* the case. To

examine the differences in accuracy rates across vowels and gates within the second

pilot study, a statistical mixed-effects model was run in SAS to test whether various

factors had an effect on accuracy, the dependent variable. The fixed effects in the

model were: vowel type, gate, and word, which was nested within vowel type. The

model also included a random effect for subject, and one for block (1-5, the repetition

number of a given stimulus). The main effect of vowel type was highly significant

($F(3, 3884) = 5.04$; $p = 0.0017$), as was that of word ($F(24, 3884) = 2.02$; $p = 0.0023$),

and that of gate ($F(3, 3884) = 3.22$; $p = 0.0219$).[45] The accuracy outcome for each

vowel type (/ʌ/, /ɨ/, /e/) was significantly different from that of the reference type (/i/),

---

[44] Ratings could go as low as 1, but since ratings in general were very high, the x-axis has been adjusted
to show differences clearly.
[45] A model including an interaction term between vowel type and gate found that the interaction was
insignificant, meaning that the relationship between gate and identification accuracy did not vary
significantly across vowels.

indicating that the differences between participants' accuracy rate for identifying /i/ –
which was very high – and those of other vowels were significant. For /ʌ/: t(3884) =
-2.27, p = 0.0235; for /ɨ/, t(3884) = -3.08, p = 0.0021; for /e/, t(3884) = -2.01, p =
0.0446. The random factors included in the model had small effects: the covariance
parameter estimate for Subject was 0.07411 (std. err. 0.1063); and for Block, it was
1.24^{e-17} (std. err. not available).

Overall, the present model shows us that /i/ out-performs the other *three*
vowels in terms of identifiability. This suggests that /e/, /ʌ/ and /ɨ/ are all in the same
perceptual category in terms of the ease with which they may be identified. While
there is anecdotal evidence (in the tables above, and from post-experimental
questionnaires) to suggest that the central vowels are more difficult to identify, the
present study does not support it. This suggests two things: first, that /ɨ/ and /ʌ/ are not
inherently more difficult to identify than other, more solidly-phonemic vowels (i.e.
/e/); second, that /i/ is in a category of its own, perceptually. This is likely related to its
extreme, peripheral phonetic realization.

Secondly, the model confirms that both word and gate are relevant for vowel
identification. The effects of gate are statistically consistent across vowel types. There
may also be a pattern in effects on accuracy at the word level, potentially related to
lexical frequency, but we cannot identify that pattern with the resources presently
available on token frequency in Romanian.

A.5.   **Conclusions**

Whalen, Best and Irwin begin a perceptual study of allophonic variation of
aspiration in English with the expectation that when an allophone appears in an
inappropriate context, it should be more easily confused with its appropriate
counterpart (1997:503). They note that within the framework of Articulatory

Phonology (Browman & Goldstein 1986; Browman & Goldstein 1989; Browman & Goldstein 1992; Browman & Goldstein 1995), there is "an implicit prediction about what will happen if the range of automatic [phonetic] variation is exceeded. Listeners should perceive a difference if the variation is sufficient to constitute a lexical difference, and they should be relatively insensitive to the difference if it is not enough to signal a meaningful distinction in the language" (Whalen, Best and Irwin 1997:503-504). By this description, it is clear that in most cases, Romanian listeners in the present experiment were able to consistently perceive such a difference, which constitutes a meaningful distinction to be treated as any other contrast. This discrimination may have been helped by the structure of the task, which was a forced categorization task rather than the ABX task used by Whalen et al. (1997), which does not assume discrete categories.

With regard to the misidentifications that do occur in these data, some observations may be made. Miller and Nicely (1955) point out that perceptual confusions do not occur randomly, in their work examining confusion rates of acoustically-filtered consonants. They find that cues to voicing, nasalization, frication, place of articulation and duration may be treated as separate and independent channels of information. In my experiment, which focuses on vowels rather than consonants, the main channels which can be disrupted by the gating methodology are duration, which is known to be a factor that differs based on vowel height, and formant structure, which is analogous to place of articulation. Since filtering does not occur in this experiment, the only disruption of acoustic cues that occurs in the stimuli is mediated by durational alterations. In all cases, longer stimuli should be more easily perceived, because participants hear more acoustic material and greater portions of cues that indicate vowel quality (transitions, steady-state formant values,

coarticulation with upcoming segments). Generally, listeners are least successful at identifying short stimuli, and more successful at all the longer gate lengths.

Across the two pilot studies, the experimental hypothesis was that the marginal phonological contrastiveness of /ʌ/ and /ɨ/ correlates with an increased rate of confusion between them. This was partially confirmed: specifically, /ʌ/ is misidentified as /ɨ/ more often than as any other vowel; and the greatest likelihood of confusion across contexts is between /ʌ/ and /ɨ/. If the high rates of confusion for /ʌ/ were triggered solely by its acoustic proximity to other vowels and its placement squarely in the middle of Romanian vowel space, we might predict equal confusion rates of /ʌ/ with /ɨ/ and /e/. Instead, /ʌ/ is confused with /ɨ/ at a higher rate than it is confused with other vowels. However, the inverse is not true, especially in the second pilot study: when /ɨ/ is misidentified, it is more often confused with /e/ than /ʌ/. Given the marginal contrastiveness hypothesis alone, it is not clear why this should be the case; in fact, a combination of factors is likely at work. Listeners use the acoustic distinctiveness of each vowel to a high degree of success (particularly for acoustically-extreme /i/), but unquantified differences in syllable frequency may also play a role. We also find variation in identification rates across different words, within the second pilot study; these discrepancies suggest that vowel quality alone is not responsible for facilitating identification, and that surrounding context is highly relevant.

It may be that contextual phonological frequency effects outweigh any lexical frequency effects, and may increase the likelihood that a listener chooses /ɨ/ upon hearing /ʌ/. In this study calculations supporting the marginal contrast between /ɨ/ and /ʌ/ are based on phoneme type frequency, which has guided interpretation of perceptual results in English, namely that listeners' identification of consonant clusters is affected by statistical properties of the lexicon (Hay, Pierrehumbert & Beckman 2003). However, more stringent controls of the corpus are necessary to calculate type

frequency based on phonemes' presence in monomorphemic roots (Pierrehumbert 2003b). Where interaction occurs between phonology and the lexicon, exemplar theory (Pierrehumbert 2001) is another guiding principle, suggesting that speakers' linguistic representations are affected by the full range of phonetic realizations they experience for a particular form. From this point of view, token frequency is the crucial predictor of linguistic output (Jurafsky, Bell & Girand 2002), and it could also influence perception of vowel quality in contexts of differing relative frequencies. A thorough investigation of the relative effects of type and token frequency requires a more complex experimental design, and is thus left for future research.

APPENDIX D   Mean formant values for male speakers in nonce

words (coarticulation study)

Table A.6.   **Mean formant values for male speakers by preceding vowel**

	Italian – F1						Italian – F2					
	V_1 = /a/			V_1 = /i/			V_1 = /a/			V_1 = /i/		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	822	108	70	824	113	70	1385	90	70	1383	83	70
e	484	155	72	482	157	71	1959	89	72	1959	93	71
i	285	32	71	273	20	71	2279	215	71	2313	230	71
o	645	71	71	633	79	71	986	117	71	988	108	71
u	326	36	72	318	33	71	769	92	72	783	113	71
	Romanian – F1						Romanian – F2					
	V_1 = /a/			V_1 = /i/			V_1 = /a/			V_1 = /i/		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	804	52	24	794	55	24	1313	102	24	1348	123	24
e	470	47	24	485	58	24	2065	135	24	2076	127	24
ʌ	509	38	23	537	52	24	1376	220	23	1410	213	24
ea	750	41	24	749	55	24	1782	137	24	1774	125	24
i	284	13	25	278	14	22	2264	75	25	2289	89	22
ɨ	365	39	25	348	25	24	1525	253	25	1507	279	24
o	491	25	24	513	53	23	999	112	24	1019	138	23
oa	690	37	24	721	45	25	1135	63	24	1165	87	25
u	347	24	24	351	27	24	994	185	24	1041	228	24

Table A.7.   **Mean formant values for male speakers by following vowel**

	Italian – F1						Italian – F2					
	V_3 = /a/			V_3 = /i/			V_3 = /a/			V_3 = /i/		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	817	107	68	829	114	72	1370	86	68	1397	86	72
e	492	160	72	475	151	71	1940	93	72	1978	85	71
i	277	26	70	281	29	72	2289	205	70	2303	239	72
o	642	74	71	636	76	71	986	113	71	988	113	71
u	323	35	72	321	35	71	767	107	72	785	99	71
	Romanian – F1						Romanian – F2					
	V_3 = /a/			V_3 = /i/			V_3 = /a/			V_3 = /i/		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	813	56	24	784	46	24	1297	107	24	1365	111	24
e	516	45	24	438	20	24	1964	77	24	2177	67	24
ʌ	549	46	23	498	34	24	1344	187	23	1441	232	24
ea	771	43	24	727	42	24	1675	68	24	1881	88	24
i	285	13	24	277	14	23	2259	72	24	2294	89	23
ɨ	365	36	25	348	29	24	1458	237	25	1576	280	24
o	514	32	23	490	48	24	992	103	23	1024	143	24
oa	712	32	25	699	53	24	1137	71	25	1164	81	24
u	348	25	24	350	27	24	973	208	24	1062	200	24

Table A.8.　**Mean formant values for male speakers by preceding consonant**

	Italian – F1						Italian – F2					
	$C_2 = /a/$			$C_2 = /i/$			$C_2 = /a/$			$C_2 = /i/$		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	816	106	69	831	115	71	1361	89	69	1407	79	71
e	491	154	70	476	157	73	1929	98	70	1988	72	73
i	285	30	72	273	24	70	2291	227	72	2301	219	70
o	641	71	71	637	79	71	981	114	71	993	112	71
u	327	34	71	317	35	72	762	97	71	790	107	72

	Romanian – F1						Romanian – F2					
	$C_2 = /a/$			$C_2 = /i/$			$C_2 = /a/$			$C_2 = /i/$		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	797	60	24	800	46	24	1276	101	24	1385	99	24
e	491	60	24	463	39	24	2055	133	24	2086	127	24
ʌ	538	39	24	508	51	23	1305	236	24	1485	143	23
ea	764	47	24	734	45	24	1748	115	24	1808	139	24
i	283	15	24	279	12	23	2279	70	24	2272	94	23
ɨ	368	24	24	346	38	25	1395	293	24	1633	165	25
o	503	45	23	500	41	24	945	116	23	1070	101	24
oa	702	38	25	709	50	24	1103	50	25	1200	69	24
u	355	24	24	344	26	24	882	165	24	1154	146	24

Table A.9.　**Mean formant values for male speakers by following consonant**

	Italian – F1						Italian – F2					
	$C_3 = /a/$			$C_3 = /i/$			$C_3 = /a/$			$C_3 = /i/$		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	840	109	72	806	110	68	1370	84	72	1399	87	68
e	475	154	73	492	157	70	2005	75	73	1911	81	70
i	276	31	72	282	24	70	2323	217	72	2268	225	70
o	624	70	72	655	77	70	942	112	72	1034	94	70
u	325	35	73	319	35	70	736	79	73	818	109	70

	Romanian – F1						Romanian – F2					
	$C_3 = /a/$			$C_3 = /i/$			$C_3 = /a/$			$C_3 = /i/$		
V_2	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
a	803	41	24	794	63	24	1271	102	24	1390	92	24
e	487	58	24	467	46	24	2103	126	24	2038	127	24
ʌ	526	38	24	520	56	23	1225	154	24	1570	88	23
ea	755	44	24	743	52	24	1784	114	24	1772	146	24
i	274	10	24	289	13	23	2306	84	24	2245	67	23
ɨ	364	32	24	350	34	25	1324	225	24	1701	133	25
o	485	34	24	519	43	23	935	129	24	1086	53	23
oa	709	22	24	702	58	25	1132	84	24	1167	66	25
u	362	20	24	337	24	24	902	203	24	1133	135	24

Table A.10.   **Differences by vowel context**

V₂	Italian - F1 Mean(a) - Mean(i)		Italian - F2 Mean(a) - Mean(i)	
	V₁	V₃	V₁	V₃
a	-2	-12	2	-27
e	2	17	0	-38
i	13	-3	-34	-15
o	12	6	-1	-2
u	7	2	-15	-18

V₂	Romanian - F1 Mean(a) - Mean(i)		Romanian - F2 Mean(a) - Mean(i)	
	V₁	V₃	V₁	V₃
a	10	29	-35	-68
e	-15	78	-11	-214
ʌ	-28	51	-33	-96
ea	1	44	8	-205
i	6	8	-25	-35
ɨ	17	16	18	-118
o	-22	23	-20	-32
oa	-31	13	-31	-28
u	-4	-2	-48	-89

Table A.11.   **Differences by consonant context**

V₂	Italian - F1 Mean(p) - Mean(tʃ)		Italian - F2 Mean(p) - Mean(tʃ)	
	C₂	C₃	C₂	C₃
a	33	-15	-30	-46
e	-18	15	94	-59
i	-5	12	55	-10
o	-31	5	-92	-13
u	6	11	-82	-29

V₂	Romanian - F1 Mean(p) - Mean(ts)		Romanian - F2 Mean(p) - Mean(ts)	
	C₂	C₃	C₂	C₃
a	9	-3	-118	-108
e	20	28	66	-31
ʌ	6	30	-345	-180
ea	12	30	11	-60
i	-15	4	61	7
ɨ	14	22	-377	-238
o	-35	2	-151	-125
oa	7	-8	-35	-97
U	25	11	-231	-272

REFERENCES

Agard, Frederick Browning. 1958. *Structural Sketch of Rumanian*. (Language Monographs no. 26). Baltimore: Linguistic Society of America.

Alkire, Ti & Carol Rosen. 2010. *Romance Languages: A Historical Introduction*. Cambridge University Press.

Archangeli, Diana B. 1988. Aspects of underspecification theory. *Phonology* 5(02). 183–207.

Archangeli, Diana B. & Douglas George Pulleyblank. 1994. *Grounded Phonology*. (Current Studies in Linguistics 25). Cambridge, Mass: MIT Press.

Augerot, James E. 1974. *Romanian Phonology: A Generative Phonological Sketch of the Core Vocabulary of Standard Romanian*. Bucharest, Romania and Moscow, Idaho: Editura Academiei Republicii Socialiste România; Idaho Research Foundation, University of Idaho.

Avram, Andrei. 1958. Semivocalele româneşti din punct de vedere fonologic [Romanian semivowels from a phonological perspective]. *Studii şi cercetări lingvistice* 9. 1–7.

Avram, Andrei. 1991. Semivocalele, semiconsoanele şi pseudovocalele în română [Semi-vowels, semi-consonants and pseudo-vowels in Romanian]. *Studii şi cercetări lingvistice* 5/6. 213–229.

Avram, Andrei. 2000. *Probleme de Etimologie*. (Etymologica 4). Bucureşti: Univers enciclopedic.

Beckman, Jill N. 1997. Positional Faithfulness, Positional Neutralisation and Shona Vowel Harmony. *Phonology* 14(1). 1–46.

Beddor, Patrice S., J. D. Harnsberger & S. Lindemann. 2002. Language-specific patterns of vowel-to-vowel coarticulation: Acoustic structures and their perceptual correlates. *Journal of Phonetics* 30(4). 591–627.

Beddor, Patrice S., R. A. Krakow & S. Lindemann. 2001. Patterns of perceptual compensation and their phonological consequences. *The role of speech perception in phonology*. 55–78.

Beddor, Patrice S. & H. K. Yavuz. 1995. The relation between vowel-to-vowel coarticulation and vowel harmony in Turkish. *Proceedings of the 16th International Congress of Phonetic Sciences* vol. 2. 44–51.

Bell-Berti, F. & K. S. Harris. 1976. Some aspects of coarticulation. *Haskins Laboratories Status Report on Speech Research*. 197–204.

Bennett, D. C., Z. Jia-lu, L. Shi-nan, H. Xing-hui, V. Hazan & A. Abakuks. 1992. Universal and Language-Specific Aspects of Vowel Perception. *Proceedings of the 14th International Congress of Acoustics*.

Blevins, Juliette. 2004. *Evolutionary Phonology: The Emergence of Sound Patterns*. Cambridge, UK; New York: Cambridge University Press.

Blevins, Juliette. 2006. A theoretical synopsis of Evolutionary Phonology. *Theoretical Linguistics* 32(2). 117–166.

Boersma, Paul & D. Weenink. 2010. *Praat: Doing phonetics by computer [Computer program], Version 5.42*. http://www.fon.hum.uva.nl/praat/.

Boia, Lucian. 2001. *Romania: Borderland of Europe*. (Topographics). London: Reaktion.

Boyce, Susan E. 1990. Coarticulatory organization for lip rounding in Turkish and English. *Journal of the Acoustical Society of America* 88(6). 2584–2595.

Bradlow, Ann R. 1996. A Perceptual Comparison of the /i/–/e/ and /u/–/o/ contrasts in English and in Spanish: Universal and Language-Specific Aspects. *Phonetica* 53(1-2). 55–85.

Bradlow, Ann R. 1993. Language-specific and universal aspects of vowel production and perception: A cross-linguistic study of vowel inventories. Ithaca NY: Cornell University. Ph.D. dissertation.

Browman, Catherine P. & Louis Goldstein. 1986. Towards an articulatory phonology. *Phonology Yearbook* 3. 219–252.

Browman, Catherine P. & Louis Goldstein. 1989. Articulatory gestures as phonological units. *Phonology* 6(2). 201–251.

Browman, Catherine P. & Louis Goldstein. 1992. Articulatory phonology: An overview. *Phonetica* 49(3-4). 155–180.

Browman, Catherine P. & Louis Goldstein. 1995. Gestural syllable position effects in American English. *Producing Speech: Contemporary Issues. For Katherine Safford Harris*. 19–34. New York: AIP Press.

Chen, Yiya. 2008. The acoustic realization of vowels of Shanghai Chinese. *Journal of Phonetics* 36(4). 629–648.

Chiţoran, Ioana. 2002a. A perception-production study of Romanian diphthongs and glide-vowel sequences. *Journal of the International Phonetic Association* 32(2). 203–222.

Chiţoran, Ioana. 2002b. *The Phonology of Romanian: A Constraint-Based Approach*. (Studies in Generative Grammar 56). Berlin; New York: Mouton de Gruyter.

Chiţoran, Ioana. 2002c. The phonology and morphology of Romanian diphthongization. *Probus* 14(2). 205–246.

Chiţoran, Ioana & Abigail C. Cohn. 2009. Complexity in phonetics and phonology: gradience, categoriality, and naturalness. *Approaches to Phonological Complexity*, 21-46. Berlin; New York: Mouton de Gruyter.

Chiţoran, Ioana & José Ignacio Hualde. 2007. From Hiatus to Diphthong: The Evolution of Vowel Sequences in Romance. *Phonology* 24(1). 37–75.

Chomsky, Noam & Morris Halle. 1968. *The Sound Pattern of English*. New York: Harper & Row.

Cioranescu, A. 2002. *Dicţionarul etimologic al limbii române [Etymological dictionary of the Romanian language]*. Bucharest: Editura Saeculum IO.

Close, Elizabeth. 1974. *The Development of Modern Rumanian; Linguistic Theory and Practice in Muntenia 1821-1838*. (Oxford Modern Languages and Literature Monographs). London; New York: Oxford University Press.

Cohn, Abigail C. 1998. The Phonetics-Phonology Interface Revisited: Where's Phonetics? *Texas Linguistic Society 1998 Conference Proceedings* vol. 41. 25–40.

Cohn, Abigail C. 2006. Is there Gradient Phonology? In Gisbert Fanselow, Caroline Fry, Ralf Vogel & Matthias Schlesewsky (eds.), *Gradience in Grammar: Generative Perspectives*, 25–44. Oxford: Oxford University Press.

Cohn, Abigail C. 2007. Phonetics in phonology and phonology in phonetics. *Working Papers of the Cornell Phonetics Laboratory* 16. 1–31.

Coteanu, Ion. 1981. *Structura şi evoluţia limbii române (de la origini pînă la 1860) [The structure and evolution of the Romanian language (from its origins until 1860)]*. Bucureşti: Editura Academiei Republicii Socialiste România.

Crawford, Clifford James. 2009. Adaptation and Transmission in Japanese Loanword Phonology. Ithaca, NY: Cornell University. Ph.D. dissertation.

Crothers, J. 1978. Typology and universals of vowel systems. *Universals of human language* 2. 93–152.

Crystal, T. H. & A. S. House. 1988. The duration of American-English vowels: An overview. *Journal of Phonetics* 16(3). 263–284.

Cueşdean, Lucian Iosif. 2006. *Româna, Limba Vechii Europe*. Bucureşti: Editura Solif.

DEX, Online. 2011. Dicţionar explicativ al limbii române [Explanatory dictionary of the Romanian language]. Searchable electronic dictionary. http://dexonline.ro/ (11 November, 2011).

Dimitrescu, Florica. 1973. *Contribuţii la Istoria Limbii Române Vechi [Contributions to the History of Old Romanian]*. Bucureşti: Editura didactică şi pedagogică.

Disner, S.F. 1983. Vowel Quality: The Relation between Universal and Language Specific Factors. *UCLA Working Papers in Linguistics* vol. 58.

Dobson, E. J. 1968. *English Pronunciation 1500-1700*. 2nd ed. Oxford: Clarendon Press.

DuNay, André. 1977. *The Early History of the Rumanian Language*. (The Edward Sapir Monograph Series in Language, Culture, and Cognition 3). Lake Bluff, Ill: Jupiter Press.

Ernestus, Mirjam. 2006. Statistically gradient generalizations for contrastive phonological features. *The Linguistic Review* 23(3). 217–233.

Ethnologue. 2011. Romanian. http://www.ethnologue.com/show_language.asp?code=ron (13 October, 2011).

Evdoshenco, A. 1961. "Diftongii" ea, oa şi locul lor în sistemul vocalic al limbii române [The diphthongs ea, oa and their place in the vocalic system of Romanian]. *Studii şi cercetări lingvistice* 12/4. 463–466.

Fagyal, Z., N. Nguyen & P. Boula De Mareüil. 2003. From dilation to coarticulation: is there vowel harmony in French? *Studies in the Linguistic Sciences* 32(2). 1–21.

Ferragne, Emmanuel, Nathalie Bedoin, Véronique Boulenger & François Pellegrino. 2011. The perception of a derived contrast in Scottish English. *Proceedings of the International Congress of Phonetic Sciences, Hong Kong*. 667-670.

Flanagan, J. L. 1955. A difference limen for vowel formant frequency. *The Journal of the Acoustical Society of America* 27(3). 613–617.

Flege, J. E., M. J. Munro & R. A. Fox. 1995. The perception of English and Spanish vowels by native English and Spanish listeners: A multidimensional scaling analysis. *Journal of the Acoustical Society of America* 97. 2540–2551.

Flemming, E. & S. Johnson. 2007. Rosa's roses: reduced vowels in American English. *Journal of the International Phonetic Association* 37(1). 83–96.

Fowler, Carol A. 1981. Production and perception of coarticulation among stressed and unstressed vowels. *Journal of Speech and Hearing Research* 24(1). 127.

Francis, W. N. & H. Kucera. 1967. *Computational analysis of present-day American English*. Providence, RI: Brown University Press.

Friesner, M. L. 2009. The adaptation of Romanian loanwords from Turkish and French. In Andrea Calabrese & W. Leo Wetzels (eds.), *Loan phonology*, 115–129. Philadephia: John Benjamins Publishing Company.

Frunza, Gabriela. 2011. Interacţiunea dintre vocale şi triftongi în limba română literară şi în rostirea spontană [Interaction between vowels and triphthongs in literary Romanian and in spontaneous speech]. Chişinău, Moldova: Institute of Philology of the ASM. Ph.D. dissertation.

Gheţie, Ion. 1974. *Inceputurile Scrisului în Limba Română. Contribuţii Filologice şi Lingvistice [The Beginnings of Writing in the Romanian Language. Filological and Linguistic Contributions]*. Bucureşti: Editura Academiei Republicii Socialiste România.

Goldsmith, John A. 1995. Phonological Theory. In John A. Goldsmith (ed.), *The Handbook of Phonological Theory*, 1–23. Cambridge, MA: Blackwell Publishers.

Graur, A. & Alexandru Rosetti. 1938. Esquisse d'une phonologie du roumain. *Buletin Linguistique* 6. 5–29.

Grecu, Victor V. 1971. *Studii de Istorie a Lingvisticii Româneşti [Studies on the History of Romanian Linguistics]*. Bucureşti: Editura didactică şi pedagogică.

Greenberg, J.H. 1966. Synchronic and diachronic universals in phonology. *Language* 42(2). 508–517.

Hall, Kathleen Currie. 2009. A Probabilistic Model of Phonological Relationships from Contrast to Allophony. Columbus OH: The Ohio State University Ph.D. dissertation.

Hall, Robert A. 1974. *External History of the Romance Languages*. New York: American Elsevier Publishing Company.

Hamano, Shoko. 1998. *The Sound-Symbolic System of Japanese*. (Studies in Japanese Linguistics). Stanford, California: CSLI Publications.

Havránek, B. 1933. *Zur phonologischen geographie: das Vokalsystem des Balkanischen Sprachbundes*. Imprimerie de Joh. Enschedé et fils.

Hay, Jennifer, Janet B. Pierrehumbert & Mary E Beckman. 2003. Speech perception, well-formedness and the statistics of the lexicon. In John Local, Richard Ogden & Rosalind Temple (eds.), *Papers in Laboratory Phonology VI: Phonetic interpretation*, 58-74. Cambridge, UK: Cambridge University Press.

Hockett, C. F. 1966. *The quantification of functional load: A linguistic problem*. Memorandum. (U.S. Air Force).

House, A. S & G. Fairbanks. 1953. The influence of consonant environment upon the secondary acoustical characteristics of vowels. *Journal of the Acoustical Society of America* 25(1). 105–113.

Hualde, José Ignacio. 2004. Quasi-phonemic contrasts in Spanish. *WCCFL 23: Proceedings of the 23rd West Coast Conference on Formal Linguistics*, 374–98.

Hualde, José Ignacio & Ioana Chiţoran. 2003. Explaining the distribution of hiatus in Spanish and Romanian. *Proceedings of the 15th International Congress of Phonetic Sciences*. 3013–3016.

Hyman, Larry M. 1975. *Phonology: Theory and Analysis*. New York: Holt, Rinehart and Winston.

Hyman, Larry M. 2005. Diachrony proposes, synchrony disposes: Evidence from prosody and chess. *"Synchrony meets Diachrony in Phonology," GLOW. Université de Genève, March 30, 2005*.

Hyman, Larry M. 2008. Universals in phonology. *The linguistic review* 25(1-2). 83–137.

Itô, J. & A. Mester. 1995. The core-periphery structure of the lexicon. *University of Massachusetts Occasional Papers* 18. 181–209.

Ivănescu, G. 1980. *Istoria Limbii Române [History of the Romanian language]*. Iaşi: Editura Junimea.

Ivănescu, G. 2000. *Istoria Limbii Române [History of the Romanian language]*. Iaşi: Editura Junimea.

Jakobson, Roman, Gunnar Fant & Morris Halle. 1963. *Preliminaries to Speech Analysis: The Distinctive Features and Their Correlates*. 3rd ed. Cambridge, MA: M.I.T. Press.

Johnson, Keith. 1997. *Acoustic and Auditory Phonetics*. Cambridge, MA: Blackwell Publishers.

Jongman, A., M. Fourakis & J. A. Sereno. 1989. The acoustic vowel space of modern Greek and German. *Language and Speech* 32(3). 221–248.

Jurafsky, D., A. Bell & C. Girand. 2002. The role of the lemma in form variation. In Carlos Gussenhoven & Natasha Warner (eds.), *Laboratory Phonology 7*, 3–34. Berlin; New York: Mouton de Gruyter.

Kenstowicz, M. 2010. Vocale Incerta, Vocale Aperta. http://web.mit.edu/~linguistics/people/faculty/kenstowicz/kenstowicz-2.pdf (20 November, 2011).

Kent, Raymond D. & Charles Read. 1992. *The Acoustic Analysis of Speech*. San Diego, California: Singular Publication Group.

King, Robert D. 1967. Functional Load and Sound Change. *Language* 43(4). 831–852.

Kiparsky, Paul. 2003. The Phonological Basis of Sound Change. In Brian D Joseph & Richard D Janda (eds.), *The Handbook of Historical Linguistics*, 313–342. Malden, MA: Blackwell Publishers.

Klatt, D. H. 1973. Interaction between two factors that influence vowel duration. *The Journal of the Acoustical Society of America* 54(4). 1102–1104.

Klatt, D. H. 1976. Linguistic uses of segmental duration in English: Acoustic and perceptual evidence. *The Journal of the Acoustical Society of America* 59(5). 1208–1221.

Ladd, D. R. 2006. "Distinctive phones" in surface representation. In Louis Goldstein, D. H. Whalen & Catherine T. Best (eds.), *Laboratory Phonology 8*, 3–26. Berlin; New York: Mouton de Gruyter.

Ladefoged, Peter & Keith Johnson. 2011. *A Course in Phonetics*. 6th ed. Boston, MA: Wadsworth, Centage.

Lahiri, A. & W. Marslen-Wilson. 1991. The mental representation of lexical form: A phonological approach to the recognition lexicon. *Cognition* 38(3). 245–294.

Lehiste, Ilse. 1972. The timing of utterances and linguistic boundaries. *Journal of the Acoustical Society of America* 58(6B). 2018-2024.

Lehiste, Ilse. 1970. *Suprasegmentals*. Cambridge, MA: M.I.T. Press.

Levelt, W. J. M. 1989. *Speaking: From Intention to Articulation*. Cambridge, MA: M.I.T. Press.

Liljencrants, J. & B. Lindblom. 1972. Numerical simulation of vowel quality systems: the role of perceptual contrast. *Language* 48(4). 839–862.

Lindau, M. & P. Wood. 1977. Acoustic vowel spaces. *UCLA Working Papers in Phonetics* 38. 41–48.

Lindblom, B. 1986. Phonetic universals in vowel systems. In John J. Ohala & Jeri J. Jaeger (eds.), *Experimental phonology*, 13–44. Orlando, Florida: Academic Press.

Lindblom, B., P. MacNeilage & M. Studdert-Kennedy. 1984. Self-organizing processes and the explanation of language universals. In Brian Butterworth, Bernard Comrie & Östen Dahl (eds.), *Explanations for language universals*, 181–203. New York: Mouton.

Luick, Karl. 1940. *Historische Grammatik der englischen Sprache*. Leipzig: C. H. Tauchniz.

Maddieson, Ian. 1984. *Patterns of sounds*. Cambridge: Cambridge University Press.

Maddieson, Ian. 1985. Phonetic Cues to Syllabification. In Victoria Fromkin (ed.), *Phonetic linguistics: Essays in honor of Peter Ladefoged*. Orlando, Florida: Academic Press, Inc.

Maddieson, Ian & Kristin Precoda. 1990. Updating UPSID. *UCLA Working Papers in Phonetics* 74. 104–111.

Magen, H. 1984. Vowel-to-vowel coarticulation in English and Japanese. Paper presented at the 107th Meeting of the Acoustical Society of America.

Mallinson, George. 1988. Romanian. In Martin Harris & Nigel Vincent (eds.), *The Romance Languages*, 391–419. London & Sidney: Croom Helm.

Mancaș, Mihaela. 1974. *Istoria Limbii Române Literare: Perioada Modernă: Secolul al XIX-Lea [History of Literary Romanian: The Modern Period: The 19th Century]*. București: CMUB.

Maneca, C. 1966. La struttura etimologica della lingua romena letteraria contemporanea dal punto di vista della frequenza dei vocaboli [The etymological structure of the Romanian language from the point of view of word frequency]. *Revue roumaine de linguistique* 11(3). 219–237.

Manolescu, A., D. Olson & M. Ortega-Llebaria. 2009. Cues to Contrastive Focus in Romanian. In Marina Cláudia Vigário, Sonia Frota & Maria João Freitas (eds.), *Phonetics and Phonology: Interactions and interrelations*, vol. 306, 71–90. Amsterdam: John Benjamins Publishing Company.

Manuel, Sharon Y. 1990. The role of contrast in limiting vowel-to-vowel coarticulation in different languages. *Journal of the Acoustical Society of America* 88(3). 1286–1298.

Manuel, Sharon Y. 1999. Cross-language studies: relating language-particular coarticulation patterns to other language-particular facts. In William J Hardcastle & Nigel Hewlett (eds.), *Coarticulation: Theory, Data, and Techniques*, 179–199. Cambridge, UK: Cambridge University Press.

Manuel, Sharon Y. & R. A. Krakow. 1984. Universal and language particular aspects of vowel-to-vowel coarticulation. *Haskins Laboratories Status Report on Speech Research* SR-77/78. 69–78.

Marin, Stefania. 2005. Complex nuclei in Articulatory Phonology: The case of Romanian diphthongs. In Randall S. Gess and Edward J. Rubin (eds.), *Theoretical and experimental approaches to Romance linguistics: selected papers from the 34th Linguistic Symposium on Romance Languages (LSRL), Salt Lake City, March 2004*, 161-179. Amsterdam: John Benjamins Publishing Company.

Marin, Stefania. 2007. An articulatory modeling of Romanian diphthong alternations. *Proceedings of the International Congress of Phonetic Sciences, Saarbrücken*. 453–456.

Marin, Stefania & Louis Goldstein. 2012. A gestural model of the temporal organization of vowel clusters. In Philip Hoole, Marianne Pouplier, L Bombien, Christine Mooshammer & Barbara Kühnert (eds.), *Consonant Clusters and Structural Complexity*. ((Interface Exploration Series). Berlin: Mouton de Gruyter.

Martinet, André. 1964. *Économie des changements phonétiques; traité de phonologie diachronique*. Berne: A. Francke.

Miller, G. A. & P. E. Nicely. 1955. An analysis of perceptual confusions among some English consonants. *The Journal of the Acoustical Society of America* 27(2). 338–352.

Miroiu, Mihai. 1996. *Romanian-English, English-Romanian Dictionary*. (Hippocrene Standard Dictionary). New York: Hippocrene Books.

Moroianu, Cristian. 1995. Observaţii asupra radicalului verbelor onomatopeice [Observations on the root of onomatopoeic verbs]. *Limba Română* XLIV(3-4). 92–98.

Myers, Scott. 1997. Expressing phonetic naturalness in phonology. In Iggy Roca (ed.), *Derivations and constraints in phonology*, 125–152. Oxford: Clarendon Press.

Narayan, C. R., J. F. Werker & Patrice S. Beddor. 2010. The interaction between acoustic salience and language experience in developmental speech perception: Evidence from nasal place discrimination. *Developmental Science* 13(3). 407–420.

Nguyen, N. & Z. Fagyal. 2008. Acoustic aspects of vowel harmony in French. *Journal of Phonetics* 36(1). 1–27.

Nguyen, N., Z. Fagyal & J. Cole. 2004. Perceptual relevance of long-domain phonetic dependencies. *Proceedings of the IVth Linguistic Studies Workshop*. 173–178.

Ohala, John. 1990. The phonetics and phonology of aspects of assimilation. In John Kingston & Mary E. Beckman (eds.), *Between the Grammar and the Physics of Speech: Papers in Laboratory Phonology 1*, 258–275. Cambridge: Cambridge University Press.

Öhman, S. E. G. 1966. Coarticulation in VCV Utterances: Spectrographic Measurements. *Journal of the Acoustical Society of America* 39(1). 151–168.

Parush, Avraham, David J. Ostry & Kevin G. Munhall. 1983. A kinematic study of lingual coarticulation in VCV sequences. *The Journal of the Acoustical Society of America* 74(4). 1115–1125.

Peterson, G. E. & Ilse Lehiste. 1960. Duration of syllable nuclei in English. *Journal of the Acoustical Society of America* 32(6). 693–703.

Petrovici, Emil. 1956. Sistemul fonematic al limbii române [The phonematic system of Romanian]. *Studii şi cercetări lingvistice* 7. 7–14.

Petrovici, Emil. 1957. Interpénétration d'une phonologie slave et d'une morphologie roumane. In Iorgu Iordan, Emil Petrovici & Alexandru Rosetti (eds.), *Mélanges Linguistiques, Publiés a L'occasion du VIIIe Congrès International des Linguistes à Oslo, du 5 au 9 Août 1957*. Bucharest: Academia Republicii Populare Romîne.

Petrucci, Peter R. 1999. *Slavic Features in the History of Rumanian*. (LINCOM Studies in Romance Linguistics 08). München: LINCOM Europa.

Pierrehumbert, Janet B. 1990. Phonological and phonetic representation. *Journal of Phonetics* 18(3). 375–394.

Pierrehumbert, Janet B. 2001. Exemplar dynamics: Word frequency, lenition, and contrast. In Joan L. Bybee & Paul J. Hopper (eds.), *Frequency and the Emergence of Linguistic Structure*, 137–157. (Typological Studies in Language v. 45). Amsterdam: John Benjamins Publishing Company.

Pierrehumbert, Janet B. 2003a. Phonetic diversity, statistical learning, and acquisition of phonology. *Language and speech* 46(2-3). 115–154.

Pierrehumbert, Janet B. 2003b. Probabilistic Phonology: Discrimination and Robustness. In Rens Bod, Jennifer Hay & Stefanie Jannedy (eds.), *Probabilistic Linguistics*, 177–228. Cambridge, MA: MIT Press.

Przezdziecki, Marek A. 2005. Vowel Harmony and Coarticulation in Three Dialects of Yoruba: Phonetics Determining Phonology. Ithaca NY: Cornell University. Ph.D. dissertation.

Recasens, D. 1987. An acoustic analysis of V-to-C and V-to-V coarticulatory effects in Catalan and Spanish VCV sequences. *Journal of Phonetics* 15. 299–312.

Recasens, D. & A. Espinosa. 2006. Dispersion and variability of Catalan vowels. *Speech communication* 48(6). 645–666.

Rosetti, Alexandru. 1954. *Influenta Limbilor Slave Meridionale Asupra Limbii Române: Sec. VI-XII [The Influence of Southern Slavic Languages on the Romanian Language: 6th-12th Centuries]*. Bucureşti: Editura Academici Republicii Populare Române.

Rosetti, Alexandru. 1955. Cercetări experimentale asupra diftongilor româneşti [Experimental studies of the Romanian diphthongs]. *Studii şi cercetări lingvistice* 5. 7–27.

Rosetti, Alexandru. 1956. *Limba Romînă în Secolele al XIII-lea-al XVI-lea [The Romanian Language from the 13th to 16th Centuries]*. Bucureşti: Editura Academiei Republicii Populare Romîne.

Rosetti, Alexandru. 1958. Slavo-romanica. Sur la construction du système vocalique en roumain. *Romanoslavica* 1. 27–30.

Rosetti, Alexandru. 1959. *Recherches sur les diphtongues roumaines*. Bucharest and Copenhagen: Editura Academiei RPR & Munksgard.

Rosetti, Alexandru. 1971. *Istoria Limbii Roⁱ̂ane Literare [The History of Literary Romanian]*. Bucureşti: Minerva.

Rosetti, Alexandru. 1973a. *Études Linguistiques*. The Hague: Mouton.

Rosetti, Alexandru. 1973b. *Brève Histoire de la Langue Roumaine des Origines à Nos Jours*. (Janua Linguarum Series critica: 13). The Hague: Mouton.

Rosetti, Alexandru. 1976. Asupra monoftongării diftongului /ea/ în limba română. *Studii şi cercetări lingvistice* 27. 423–424.

Rosetti, Alexandru. 1981. Le sort du latin /i/ accentué en roumain. *Revue roumaine de linguistique* 26. 135.

Rosetti, Alexandru. 1986. *Istoria limbii române I: de la origini pînă la începtul secolului al XVII-lea [History of the Romanian language I: from its origins to the beginning of the 17th Century]*. Bucureşti: Editura Ştiinţifică şi Enciclopedică.

Saffran, J.R., R.N. Aslin & E.L. Newport. 1996. Statistical learning by 8-month-old infants. *Science* 274(5294). 1926-1928.

Sala, Marius. 1976. *Contributions à la phonétique historique du roumain*. Paris: Klincksieck.

Sala, Marius. 2005. *From Latin to Romanian: The Historical Development of Romanian in an Comparative Romance Context*. (Romance Monographs 63). University of Mississippi: Romance Monographs.

Schulte, Kim. 2005. Vowel Centralization in Romanian Verbs of Slavic Origin: Deliberate Exploitation of an Indigenous Sound Change? In Twan Geerts, Ivo van Ginneken & Haike Jacobs (eds.), *Romance languages and linguistic theory 2003: Selected papers from "Going Romance" 2003, Nijmegen, 20-22 November*, 311–326. (Amsterdam Studies in the Theory and History of Linguistic Science IV).

Schulte, Kim. 2009. Loanwords in Romanian. In Martin Haspelmath & Uri Tadmor (eds.), *Loanwords in the World's Languages: A Comparative Handbook*, 230–259. Berlin: Mouton de Gruyter.

Scobbie, James M. 2005. The phonetics phonology overlap. *QMU Speech Science Research Centre Working Papers, WP-1*.

Scobbie, James M. & Jane Stuart-Smith. 2008. Quasi-phonemic contrast and the fuzzy inventory: Examples from Scottish English.

Sohn, H. S. 2008. Phonological contrast and coda saliency of sonorant assimilation in Korean. *Journal of East Asian Linguistics* 17(1). 33–59.

Steriade, Donca. 2008. A pseudo-cyclic effect in Romanian morphophonology. In Asaf Bachrach & Andrew Nevins (eds.), *Inflectional Identity*, 313–355. Oxford: Oxford University Press.

Stevens, K. N., A. M. Libermann, M. Studdert-Kennedy & S. E. G. Öhman. 1969. Crosslanguage Study of Vowel Perception. *Language and Speech* 12(1). 1–23.

Țepelea, Gabriel. 1973. *Momente din Evoluția Limbii Române Literare [Moments in the Evolution of Literary Romanian]*. București: Editura didactică și pedagogiča.

Terbeek, D. 1977. A cross-language multidimensional scaling study of vowel perception. University of California Ph.D. dissertation.

Thurber, B.A. 2011. Voicing of Initial Interdental Fricatives in Early Middle English Function Words. *Journal of Germanic Linguistics* 23(1). 65–81.

Tilsen, Sam. 2009. Subphonemic and cross-phonemic priming in vowel shadowing: Evidence for the involvement of exemplars in production. *Journal of Phonetics* 37(3). 276–296.

Titze, Ingo R. 1989. Physiologic and acoustic differences between male and female voices. *The Journal of the Acoustical Society of America* 85(4). 1699–1707.

Trubetzkoy, N. S. 1939. *Principles of Phonology*. Trans. Christiane Baltaxe. Berkeley: University of California Press.

Ulivi, Anca. 1975. Observații asupra structurii acustice a semiconsoanelor românești [y] și [w] [Remarks on the acoustic structure of the Romanian semi-consonants [y] and [w]]. *Fonetică și dialectologie* 9. 107–112.

University of Texas at Austin. 2011. Romania Maps. *Perry-Castañeda Library Map Collection*. http://www.lib.utexas.edu/maps/romania.html (22 December, 2011).

Vasiliu, Emanuel. 1966. Towards a generative phonology of Daco-Rumanian dialects. *Journal of Linguistics* 2(01). 79–98.

Vasiliu, Emanuel. 1968. *Fonologia istorică a dialectelor dacoromâne [Historical phonology of the Dacoromanian dialects]*. București: Editura Academiei Republicii Socialiste România.

Vasiliu, Emanuel. 1990. Semivocalele românești e, i și problema non-unicității descrierilor fonologice [The Romanian semivowels e, i and the problem of the non-uniqueness of phonological descriptions]. *Studii și cercetări lingvistice* 41(3). 253–257.

Vladutu, Daniel. 2009. Romanian word list for journalistic applications. Personal communication, ms.

Walker, Rachel. 2005. Weak triggers in vowel harmony. *Natural language & linguistic theory* 23(4). 917–989.

Whalen, D. H., C. T. Best & J. R. Irwin. 1997. Lexical effects in the perception and production of American English /p/ allophones. *Journal of Phonetics* 25. 501–528.

Wikipedia. Graiul bănăţean [The language of Banat]. *Wikipedia*. http://ro.wikipedia.org/wiki/Graiul_b%C4%83n%C4%83%C8%9Bean (2 January, 2012).