CONSONANT WEAKENING IN FLORENTINE ITALIAN
AN ACOUSTIC STUDY OF GRADIENT AND VARIABLE SOUND CHANGE

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ABSTRACT

This dissertation analyzes *Gorgia Toscana*, a process in which consonants weaken in fluent speech in Tuscan Italian dialects. Previous studies (Izzo 1972; Giannelli and Savoia 1978-80; Kirchner 1998; Marotta 2001; Sorianello 2001) describe *Gorgia Toscana* as a lenition process resulting in categorical, but variable output. Categoricity is evident in these studies' reference to discrete allophonic realizations; variation is observed along several dimensions such as place of articulation, locus of weakening, and subject-specific degree of weakening. This dissertation examines acoustic data from six speakers of Florentine Italian (one thousand tokens) in order to describe the process of *Gorgia Toscana* quantitatively, and to assess the roles of physiological, perceptual, abstract cognitive, and social factors in the process.

Four acoustic correlates of lenition were measured: consonant duration, voicing, relative amplitude, and release burst. Principal Components Analysis performed on these individual measures generated a latent variable (L-score), enabling quantification of lenition for each token. Statistical analysis shows that lenition occurs at all points along a continuum, that it affects all stop consonants in the phoneme inventory (with velars leniting most, and categorically surfacing as extremely weak approximants), and that it is present to a greater or lesser extent for different speakers.

Results of this study indicate that *Gorgia Toscana* produces gradient and variable output, with certain patterns occurring in the variation. The observations that emerge from the data cannot all be accounted for if *Gorgia Toscana* is characterized as a purely phonetic, phonological, or socially-driven process of sound change. Rather, different aspects of the process are attributed to different motivators: gradience and velar-preference to articulator movements; resistance of non-velar lenition to perceptual constraints; targeting of a complete natural class and categorical weakening to abstract featural representations; and intersubject variation in velar lenition to external social factors.

It is argued that an account of the patterns observed in Florentine consonant weakening necessitates the interaction of several forces. Analysis of data from *Gorgia Toscana* contributes to the body of research on sound change and variation and serves as a basis from which to explore the interaction of forces on language structure and use.

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1 INTRODUCTION AND BACKGROUND

1.1Introduction

It is the goal of this dissertation to illustrate and account for one specific manifestation of a common lenition process, the regular weakening of consonants in Florentine (and other Tuscan varieties of) Italian known as *Gorgia Toscana* ("Tuscan throat"). Florentine provides the linguist with a rich and interesting set of data on three levels. First, its lenition patterns have not been the subject of much close phonetic analysis. Second, it exhibits a well-known, but yet unexplained, asymmetry in the extent to which consonants within natural classes weaken, an observation evident in dialectal stereotyping and previous research (Contini 1960, Giannelli and Savoia 1979/80, Lepschy and Lepschy 1977, Bafile 1997, Kirchner 1998, and others). Third, although it is a gradient process exhibiting rich variation, there are patterns observed in its history, spread, and current manifestation. If we accept that sound alternations are quantifiable, testable, and do not pattern randomly, *Gorgia Toscana* offers an interesting opportunity for analysis: it is an optimal basis for a laboratory phonological descriptive approach and a testing ground for the explanatory strength of sound-related theoretical frameworks.

As a starting point, the treatment of the sound-altering process of lenition can be divided into three broad classes: phonetic, phonological, and functional. The first of these involves spatio-temporal arrangements of articulators and speech perception, the second on abstract features and category-changing rules. The third makes use of either intrinsic factors such as lexical frequency or extrinsic social factors such as identity, community, prestige, and stigma in describing linguistic change and variation.

The frameworks described above differ in fundamental respects: whether the processes they describe are primarily driven by physical factors, by abstract featural systems, or by function. Each of these has both capabilities and limitations in its explanatory power. Physiological approaches are capable of targeting individual entities within a natural class and are gradient in nature. This level of specificity comes at a cost, however: in eschewing the role of abstract features, purely phonetic frameworks can fail to explain how a sound change might spread to or be constrained to a class of entities sharing common features that are not directly related to the physical impetus of the original alternation. On the other hand, feature-based phonological accounts are, in their most elegant forms, constrained to natural classes and are categorical in nature. Their embellishment to account for non-natural sets of linguistic entities and gradient effects nevertheless comes at the expense of simplicity and predictability. Functional approaches can be intrinsic or extrinsic. The first describes sound change as a phonetic process that is strengthened through usage, such that lexical frequency is the primary determiner (and therefore predictor) of a given type of change. Usage-based theories enjoy the advantages of capturing gradience and variation, but rely on a strong claim that requires empirical testing, and share the same deficiencies of other physiological accounts in their inability to explain the spread of a change to featurally-similar entities. Extrinsic functional accounts, à la Labov, take into consideration the role that social forces play in linguistic change and variation. Their strengths lie in the incorporation of external social factors that account for behavioral patterns in individuals and groups. On their own, however, variationist frameworks lack the explanatory power to account for the physiological aspect of sound change.

Labov (1972: 99) discusses five subtypes of linguists by analogy to their domains of research: “the library, the bush, the closet, the laboratory...the street.” The types of researcher described (in some cases pejoratively) are, respectively, the historical linguist, the anthropological linguist, the theoretical linguist, the psycholinguist, and the sociolinguist (Schilling-Estes 2002:17). Rather than point out the deficiencies of one type in an effort to boost the qualities of others, however, we should consider seriously, and objectively, the explanatory adequacy that these different types (and their associated frameworks) bring to the table.

At this dissertation’s core is the acoustic and quantitative analysis of consonants subject to weakening effects of *Gorgia Toscana*. The present study tests a number of hypotheses, whose confirmation or rejection provides insights into this particular weakening process and its patterns. Results show that *Gorgia Toscana*, while a gradient and highly variable process, can best be explained by analyzing *Gorgia* as fundamentally motivated by independent factors at different stages of its evolution. The patterns that emerge from the data provide evidence in support of a physiological force behind lenition at its onset, perceptual and phonological forces at work in its spread, and a social force playing a role in its present-day variation.

This chapter reviews the process of lenition in Section 1. Section 2 offers background in Italian phonology. Section 3 describes *Gorgia Toscana*, and discusses several former accounts of the process with an eye to building the general framework of the study herein.

The remainder of this dissertation is structured as follows:

CHAPTER 2 provides details relating to the experimental design and hypotheses. It also reports the methodology used in collecting and measuring the corpus of speech data.

CHAPTER 3 describes the data in qualitative terms and assesses the reliability of acoustic correlates of weakening.

CHAPTER 4 explains the process of quantifying lenition in via extraction of a latent variable, and provides descriptive statistics of the data.

CHAPTER 5 uses the generated latent variable to test the hypotheses that are central to this dissertation.

CHAPTER 6 discusses the explanatory power of theoretical frameworks in light of the results of this study.

1.1 Lenition

1.1.1 The process of lenition

Among phonological processes occurring in connected speech, lenition is widely observed (see the databases in Kirchner 1998, Lavoie 2001, and Gurevich 2004 for numerous examples). This weakening of consonants occurs in many, if not all, languages, both diachronically and synchronically, and includes the subcategories of voicing, fricativization, approximantization, deletion, and debuccalization. Of these subcategories, fricativization is the most common, constituting 39 of 92 examples (42.4%) in the typological data presented by Lavoie (2001). Such a pervasive process warrants both descriptive and explanatory attention: the adequacy of any theory in the domain of sound patterning in language should be judged by its ability to successfully account for lenition data.

Lenition may be described in various ways. Trask (1996) defines it as "any phonological process in which a segment becomes either less strongly occluded or more sonorous, such as k → x, x → h, or k → g." Kirchner (1998, 2001, 2004), Bybee (2001), and Pierrehumbert (2001) correlate lenition with some reduction in articulation, implying that reduced effort is responsible for weakening consonant segments. Kirchner makes use of a LAZY constraint in an Optimality Theoretic framework; Bybee and Pierrehumbert refer to it as simply "reduction." Lavoie (2001) defines it as the process by which consonants become more sonorous and less consonantal. In all of these is the underlying generalization that lenition involves change in a specific direction, with the outer limit of this change being outright deletion, and further that lenition involves weakening (hence the etymology: < L. *lenis*, 'weak'). Further, Vennemann (in personal communication with Hyman) discusses lenition as a unidirectional progression among varying degrees of weakness, such that "a segment X is said to be weaker than a segment Y if Y goes through an X stage on its way to zero."

(Hyman 1975: 165). Thus any portion of the continuum in Figure 1-1 exemplifies lenition.

Figure 1-1.
Weakening continuum
(Vennemann 1988)

-voi stop >> +voi stop >> +/- voi fricative >> approximant >> glottal >> ∅

It is not the case that segments necessarily undergo lenition only as far as the adjacent manner or voicing category. The exceptions, according to Kirchner (1998, 2004), are geminates – not shown on the scale in Figure 1-1 – which do not fricativize without first degeminating. In the domain of singleton consonants, however, voiceless stops may surface as fricatives without any obvious intermediate voicing surface representation as evidenced in Maori, Amele, and other languages. Voiced stops show alternations with approximants with no sign of surface fricativization in a variety of languages including Yana and West Tarangan. One also finds instances where voiceless stops debuccalize -- four steps away on the continuum in Figure 1-1 – in British English and West Tarangan (all data from Lavoie 2001). Table 1-1 outlines the relevant examples of these more extreme cases of lenition, all synchronic, although a number of examples in the literature also contain diachronic data.

Table 1-1.
Examples of lenition
(Lavoie 2001)

language	change	Segments
Maori	fricativization	k → x
Amele	fricativization	p → f
Yana	approximantization	b → w
West Tarangan	approximantization	g → w
British English	debuccalization	t → ʔ
West Tarangan	debuccalization	k → ʔ

1.1.2 Quantifying lenition

A significant part of this dissertation addresses the measurement of weakening. Lewis (2001) outlines five acoustic parameters that may be used to objectively verify and quantify weakening. These indicators are (1) closure duration (shorter closure = more lenition); (2) VOT (shorter VOT = more lenition); (3) percentage of closure voicing (greater percentage of voicing during closure = more lenition); (4) peak intensity (closer intensity of stop to surrounding vowels = more lenition); and (5) conservation of release burst (lack of burst = more lenition). Lavoie (2001) offers similar phonetic characteristics predictive of weakening and also includes decreased linguopalatal contact, increased formant structure, and decreased aperiodic energy. Several of these parameters are incorporated into the present study. The motivation for their selection and their reliability as lenition indicators are discussed in Chapters 2 and 3.

1.1.3 Explaining lenition

A closer look at typological lenition data is relevant to this work due to the well-documented variation in *Gorgia Toscana* effects based on place of articulation (Giannelli and Savoia 1978; Cravens 2000; Marotta 2001, 2003; Sorianello 2001, 2003). Of 71[1] diachronic and synchronic spirantization processes documented in Gurevich (2004), all available places of articulation (labial, coronal, dorsal) are represented in 32 (45%) of the processes while in the remainder only a subset of available places of articulation undergoes spirantization. In other words, approximately half of the time this form of lenition targets something less than a major natural class (such as the set of voiceless oral stops with no place of articulation distinction). We see, however, no large differences in the propensity of certain places to lenite in cases of class subsets undergoing spirantization: labials lenite in 54% of the cases where they are included in the phoneme inventory; coronals lenite 38% of the time; and dorsals 47% of the time. Looking at the entire dataset of 71 spirantization processes in which either a subset or an entire class lenites, we find that the actual rate of lenition (that is, the percentage of time a segment lenites assuming its inclusion in the phoneme inventory) is even less dependent on place of articulation: 75% for labials, 65% for coronals, and 72% for dorsals.

Coupled with the fact that few phonetic studies have been performed on data from the languages included in Gurevich's analysis, this typological overview does not

[1] Gurevich actually lists 74 processes, but three are omitted from the present analysis. Two of these, Southern Tati (Chali) and Tigrinya, lack documented phoneme inventories. The other, Amele, is omitted due to the phonemic status of the spirant.

provide evidence of regular cross-linguistic place asymmetries in lenition processes. Florentine Italian provides a rich set of relevant data to be analyzed because all of its oral stop consonants are subject to weakening and no obvious gaps are present in its phoneme inventory, yet the lenition does in fact exhibit a statistically significant bias towards velars. Furthermore, lenition in this dialect exhibits other patterns that can be used to test the explanatory power of various theoretical frameworks. The second goal of this dissertation addresses the explanation of observed lenition patterns in Florentine. We now turn to a brief background of Italian phonology and the process known as *Gorgia Toscana*.

1.2 Overview of Italian phonology and dialectal variation

1.2.1 Phonemic inventory of Italian

Table 1-2 illustrates the inventory of consonant phonemes in Italian. Fifteen of these consonants have contrastively long (geminate) correlates (Bertinetto and Loporcaro 2005: 133). The exceptions are the five segments that are intrinsically long (/ɲ/, /ʎ/, /ʃ/, /t͡s/, / d͡z /), the glides /j/ and /w/, and the postalveolar voiced fricative /ʒ/ which occurs primarily in loan words.

Note also the empty cells in the velar column of the inventory, compared with the presence of additional phonemic segments at labial and dental places of articulation. Velar obstruent phonemes consist of only the two stops, /k/ and /g/, while labial and dental phonemes include both stops and continuants.

Table 1-2.
Italian consonant inventory
(Bertinetto and Loporcaro 2005: 132)

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Palatal	Velar	Labio-Velar
Plosive	p b		t d t͡s d͡z				k g	
Nasal	m			n		ɲ		
Trill				r				
Affricate					t͡ʃ d͡ʒ			
Fricative		f v	s z		ʃ (ʒ)			
Approximant						j		w
Lateral Approximant				l		ʎ		

Following IPA standards, where symbols occur in pairs the symbol to the right represents a voiced consonant

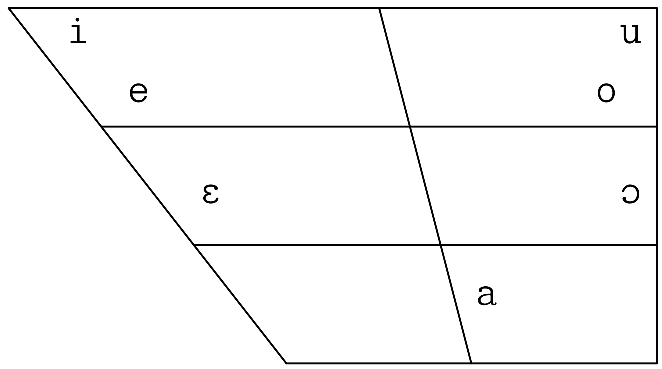
The monomorphemic minimal pairs in Table 1-3 illustrate the contrastive nature of length for many of the consonants in the Italian inventory.

Table 1-3.
Minimal pairs exhibiting singleton and geminate consonants.

	IPA	Orth.	gloss		IPA	Orth.	gloss
t	bruto	Bruto	'Brutus'	t:	brut:o	brutto	'ugly'
dʒ	modʒo	mogio	'dejected'	d:ʒ	mɔd:ʒo	moggio	'bushel'
p	papa	Papa	'Pope'	p:	pap:a	pappa	'thick soup'
m	fumo	fumo	'smoke'	m:	fum:o	fummo	'(we) were'
r	karo	caro	'dear'	r:	kar:o	carro	'cart'
l	mole	mole	'massive shape'	l:	mɔl:e	molle	'soft/weak'
n	nona	nona	'ninth (fem.)'	n:	nɔn:a	nonna	'grandmother'

Post-lexical gemination (widely known as Raddoppiamento Sintattico) also occurs in some dialects.

Table 1-4.
Italian vowel inventory
(Bertinetto and Loporcaro 2005: 136)



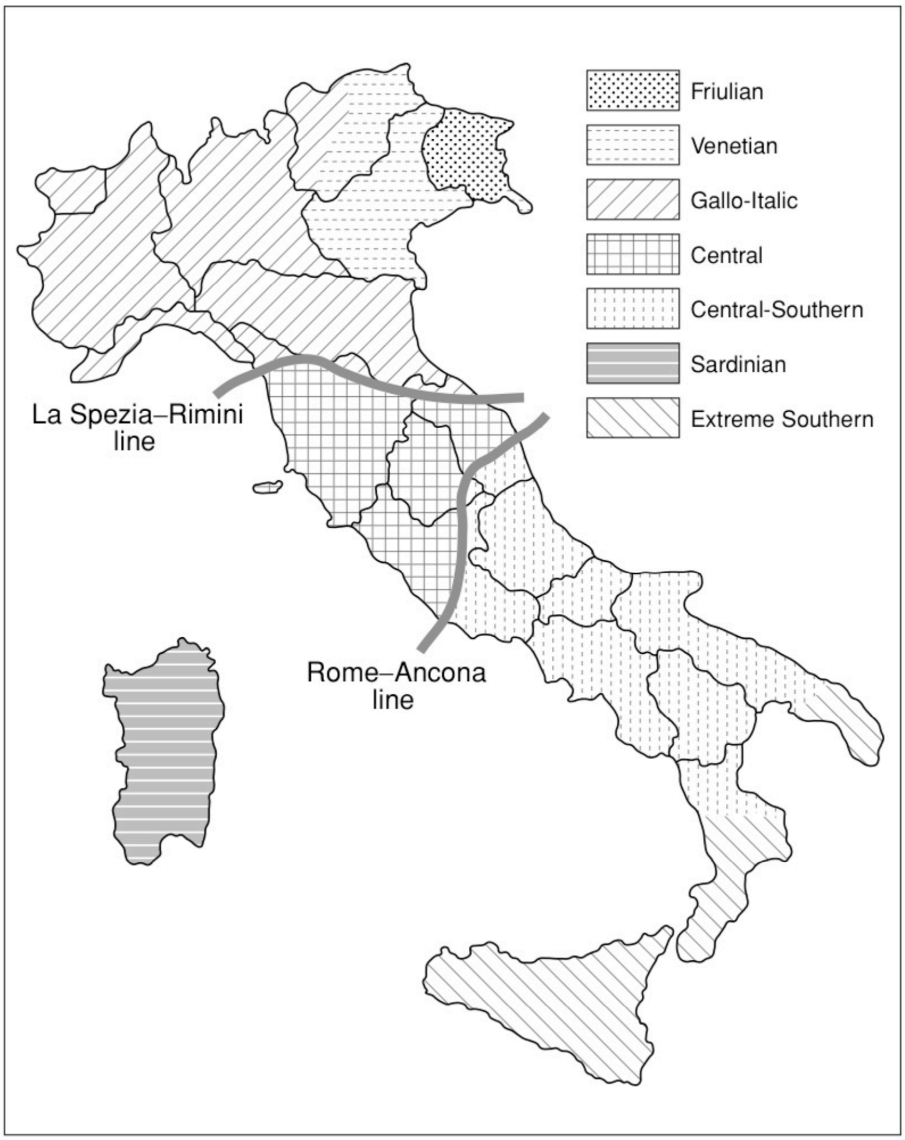
The Italian vowel system in Table 1-4 is relatively sparse, although differences between tenseness/laxness in the mid vowels may be found depending on syllable structure and lexical meaning. Tense mid vowels /e/ and /o/ are generally found in open syllables as in *neve* /neve/ 'snow' and *solo* /solo/ 'alone', while closed syllables are likely to contain the lax vowels /ɛ/ and /ɔ/, as in *terra* /tɛrːa/ 'earth' and *sogno* /sɔɲːo/ 'dream'. An exception to this syllable-related pattern occurs in certain minimal pairs like *venti* /venti/ 'twenty' vs. *venti* /vɛnti/ 'winds' and *botte* /botːe/ 'barrel' vs. *botte* /bɔtːe/ 'blows' (Lepschy 1964: 55, cited in Bertinetto and Loporcaro 2005: 136).

Vowel length, while not contrastive (Bertinetto and Loporcaro 2005: 137), exhibits surface alternations dependent on syllable structure and other prosodic environments. Vowels are generally lengthened in stressed, word-internal open syllables (with the notable lexical exceptions exemplified by the minimal pairs above) and shortened before geminate consonants and in closed syllables (Fava and Caldognetto 1976). Because vowel duration is conditioned by environment, the minimal pairs in Table 1-3 above do not indicate length changes for vowels.

1.2.2 Dialectal variation

As mentioned earlier, Italian dialectal variation is a rich source for various subfields of linguistics. Of particular note is the tripartite contrast exhibited between northern (septentrional), central, and southern (meridional) isoglosses (Rohlfs 1972), whose demarcating boundaries are commonly agreed to be the La Spezia-Rimini and Rome-Ancona lines shown in Figure 1-2. Savoia (1997) notes that these major isoglosses may be further divided as well as linked to one another – in other words, Italian dialectal variation may be considered as a continuum and not as a set of discrete region-corresponding subvarieties.

Figure 1-2.
Italian dialect map
(Kinder and Savini 2004: 3)[2]



[2] Reprinted with the permission of Cambridge University Press.

The Florentine dialect relevant to this dissertation is one of several central dialects, although the process known as *Gorgia Toscana* occurs throughout the central region in the map above. A detailed description of this process follows.

1.3 Gorgia Toscana

1.3.1 Overview of the process

The data examined are from a dialect of Italian spoken in the region of Tuscany that regularly exhibits *Gorgia Toscana* ("Tuscan throat"; henceforth *Gorgia*), a sound-changing process occurring in several Tuscan dialects of Italian. Vogel (1997) describes it as the variable phenomenon responsible for the pronunciation of /p/, /t/, and /k/ as [ɸ], [θ] and [h/x] between sonorants, resulting surface realizations not occurring in the Italian consonant inventory in Table 1-2 above. Typical examples of *Gorgia* effects are in Example 1-1.

Example 1-1.
Typical *Gorgia* effects

a.	la casa	/la kaza/	→	[la xaza / la haza / la aza]	'the house'
b.	la torta	/la tɔrta/	→	[la θɔrta]	'the cake'
c.	la palla	/la pal:a/	→	[la ɸal:a]	'the ball'

Lepschy and Lepschy (1977: 67) discuss *Gorgia* as occurring intervocalically both within the word and across words in continuous speech, and also note that spirantization of /k/ can extend as far as deletion. Many more descriptive accounts with varying focus can be found, and will be discussed in detail below. Giannelli and Savoia

(1978) present a thorough and detailed sociolinguistic description of the factors contributing to, and the continuum of surface forms resulting from variability in the application of *Gorgia*. These variables include age, gender, register, newness of topic, and emotion, to name a few. Giannelli and Cravens (1997) discuss the phenomenon in the context of other weakening processes in several Italian dialects, both historical and synchronic; Bafile (1997) describes *Gorgia* in the context of Kaye, Lowensamm, and Vergnaud's (1985) phonological element theory; Nespor and Vogel (1986) use *Gorgia* data as evidence in support of prosodic structures.

While extensive variation in the frequency and extent of lenition is attested throughout the region (Giannelli and Savoia 1978, 1979-80), the process is generally known as the intervocalic weakening of the voiceless stop consonants /p/, /t/, and /k/. Often, this weakening takes the form of fricativization to [ɸ], [θ], and [x], respectively, none of which occurs in the consonant inventory of Italian in Table 1-2. More radical alternations to debuccalization and perhaps deletion (Lepschy and Lepschy, 1977) are not uncommon.

But *Gorgia* effects are claimed to extend beyond singleton voiceless stops. According to Giannelli and Savoia's seminal work on the phenomenon, the voiced stops /b/, /d/, and /g/ are also involved in the process of weakening, surfacing as [β], [ð], and [ɣ] or [ɦ], respectively, as are the affricates /tʃ/ and /dʒ/, and the sonorants /l/, /r/, /m/, and /n/. With respect to lenition of segments other than stops, the authors claim that the affricates /tʃ/ and /dʒ/ lose their occlusive element (3. d,e); the lateral /l/ and the trill /r/ may be converted into their corresponding approximants[3] (3. f,g); and that the nasals /m/ and /n/ may surface as their corresponding nasalized approximants, or even delete altogether (3. h,i).

Examples are given below. Note that only the relevant alternations are shown in the surface forms.

Example 1-2.
Other *Gorgia* examples
(Giannelli and Savoia 1978: 44-47)[4]

a.	la gamba	/la gamba/	→	[la ɣ/ɦamba]	‘the leg’
b.	e dorme	/e dɔrme/	→	[e ðɔrme]	‘and (he/she/it) sleeps’
c.	e beve	/e beve/	→	[e βeve]	‘and (he/she/it) drinks’
d.	la cena	/la tʃena/	→	[la ʃena]	‘the dinner’
e.	i giorni	/i dʒɔrni/	→	[i ʒɔrni]	‘the days’
f.	levati	/levati/	→	[levati] ‘	‘raised (p.p.)’
g.	la cera	/la tʃera/	→	[la tʃeɹa]	‘the wax’
h.	lo mangia	/lo mãɲdʒa/	→	[lo (β̃)ãɲdʒa]	‘(he/she/it) eats it’
i.	i pane	/i pãnẽ/	→	[i pã(ɹ̃)ẽ]	‘the bread’

3 Or perhaps further approximantized, in the case of /l/, which already has approximant status (CVD).
4 All transcriptions and diacritics are those of Giannelli and Savoia and are not necessarily included in the IPA alphabet. These include subscript [‘] and [.] to indicate approximantization and increased constriction, respectively.

Effectively, then, the majority of consonants appear to lenite to some extent – particularly in Florence, considered the center in which these sound changes evolve at a more accelerated pace and are more accentuated than in other Tuscan dialects[5] (Giannelli and Savoia 1978:44). With respect to targeted items, *Gorgia* does not limit itself to content words, as evidenced by the regular inclusion of lenited function word examples in both Giannelli and Savoia (1978) and Nespor and Vogel (1986). And, finally, it should be noted that even geminates are prone to lenition: "At last, the spirantization of long [consonants] to [xː θː ɸː], realizations which are very closed and easily perceived as stops, is not rare." (Giannelli and Savoia (1978: 41).[6] This last observation stands in contradiction to Kirchner (1998: 255)'s claim that "Geminates are immune to this[7] obligatory spirantization." Examples are below.

Example 1-3.
Gorgia effects on geminates
(Giannelli and Savoia 1978: 41)[8]

a.	tappalo	/tapːalo/	→	[taɸːalo]	'he/she/it stops (it) up'
b.	è brutto	/lː e bːrutːo/	→	[lː e bːruθːo]	'he/it is ugly'
c.	è secco	/lː e sːekːo/	→	[lː e sːexːo]	'he/it is dry'

[5] "...l'uso linguistico di Firenze, che appare come il centro in cui più veloci e accelerati sono l'evoluzione ed il *cambiamento* fonetici, e più accentuata e generale è l'applicazione dei processi descritti..."
[6] "Infine, non è rara la spirantizzazione delle lunghe, che vengono realizzate ancora mediante [xː θː ɸː], realizzazioni molto chiuse e facilmente percepibili come occlusive..."
[7] Kirchner is referring specifically to the process of *Gorgia Toscana* here.
[8] Giannelli and Savoia utilize a non-IPA diacritic to indicate the relatively more closed articulation of the surface variants. It is not reproduced here.

Several authors beside Kirchner make the claim that the spirantization of singleton stops in weak or intervocalic position is obligatory. This may be the case for some speakers, particularly given Giannelli and Savoia (1978:43)'s observation of the difficulty with which speakers pronounce these stops, but acoustic studies performed by Marotta (2001, 2003) and Sorianello (2001, 2003) show that stops do, in fact, surface among the allophonic variants. Preliminary testing for the purposes of this dissertation supports the findings that *Gorgia* is far from an obligatory rule, but instead a widely distributed pattern of variation occurring optionally for a variety of speakers.

One question relevant to *Gorgia Toscana* is what type of sound-change process it is: a lexical alternation, a phonetic regularity, or a postlexical process. There is sound evidence to place it in the last of these categories. *Gorgia* is neither dependent on morphological environments, structure-preserving, nor mandatory – characteristics that easily exclude it from the class of lexical alternations (Zsiga 1995:575). Its irregularity, optionality, and variability also make it impossible to classify *Gorgia* as a phonetic regularity. But *Gorgia*'s insensitivity to grammatical information, ability to create sounds that are not in Italian's phoneme inventory, optionality, variability, and susceptibility to fast speech effects (Zsiga 1995: 577) make it a typical post-lexical process.

1.3.2 Place of articulation asymmetries

A well-known asymmetry in presence and extent of synchronic spirantization has been observed by a number of authors. Giannelli and Savoia (1978: 43) report that

Florentine speakers experience the most difficulty in producing non-fricated velars, followed by decreasing levels of difficulty for the non-fricated dentals and then non-fricated labials: "It remains to be noted that when the Florentine speaker forces himself to imitate the Standard Italian pronunciation of all three of the examined consonants, in intervocalic position, he succeeds with difficulty in pronouncing [k t p], with the level of difficulty decreasing respectively." [9] Cravens (2000: 9) refers to early 20th century observations by Rohlfs and Hall of "differential geolinguistic extension of spirantization, in which /k/ is affected in a wider area that /t/, which is in turn subject to spirantization over more territory than /p/). Bafile (1997: 28) writes "In effect, the occurrence of less-spirantized (or non-spirantized) forms becomes more frequent passing from the velar to the dental and then to the labial."[10] Anselmi (1989: 60-61) notes that "A larger quantity of carefully produced word-initial forms is observed, above all for the /k/…because this is the characteristic most noted and stigmatized in Florentine, that speakers would like to correct."[11] Sorianello (2003: 3081) finds that "the velar obstruent /k/ is the primary target of the 'gorgia', progressively followed by /t/ and /p/." Historically, one sees a similar pattern of asymmetry, which will be outlined in the following section.

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[9] "Resta da notare che quando il parlante fiorentino si sforza di imitare la pronuncia standard di tutte e tre le consonanti esaminate, in posizione intervocalica, difficilmente riesce a rendere [k t p] e con difficoltà decrescente nell'ordine."

[10] "In effetti, l'occorrenza di esiti meno spirantizzati, o (sostanzialmente) non spirantizzati, diventa più frequente passando dalla velare alla dentale e poi alla labiale."

[11] "Si è osservata una maggiore quantità di forme 'sorvegliate' in inizio di parola e soprattutto per la /k/…perché è questa la caratteristica più nota e stigmatizzata del fiorentino, che tutti i parlanti vorrebbero emendare."

Despite these synchronic and diachronic observations of place-related asymmetry, a well-known counterexample seems to exist. Giannelli and Savoia (1991) discuss the potential of /t/ to surface as /h/ (or even Ø). This fact in itself would cast doubt on any characterization of /k/ as weaker or more prone to spirantization than /t/. It appears, however, that the realization of /t/ as [h] poses no substantial counterargument, as this highly restricted alternation should be considered independently of the post-lexical process *Gorgia Toscana*.

Giannelli and Savoia (1991) observe that the /t/-[h] phenomenon is realized at the lexical phonology level (in certain dialects and registers) and thus is not influenced by rhythm, prosody, or rate. On the other hand, the spirantization discussed up until this point occurs in general contexts and is dependent on such post-lexical conditions. Radical spirantization of /t/ to [h] confines its distribution to the domain of specific verbal inflectional morphemes, as well as forms derived from inflected verbs. Thus we see the patterns in Example 1-4 surfacing.

Example 1-4.
Two weakenings of /t/

a.	finita	/finita/	→	[finiha]	but	*[finiθa]	‘finish (p.p.)’
b.	vita	/vita/	→	[viθa]	but	*[viha]	‘life’

We therefore see /t/ behaving similarly to /k/ only in certain morphological environments (and the restrictions on those environments have been relaxed somewhat, particularly in Florence). This behavior is traced back to the 19th century, based on the occurrence of the graphemes *c* and *ch* (the two orthographic representations of /k/) in the work of the playwright Giovanni Battista Zannoni (1774-1832), as reported in Izzo (1972: 39) and Giannelli and Savoia (1991: 11). Giannelli and Savoia do not offer an explanation for the origin of /t/ realized as [h], and one might ask which occurred first – a spelling change, a substitution of phonemes, or change in the pronunciation of /t/. That is, did the substitution of graphemes *c/ch* for *t* cause increased lenition in verbal inflections, was /k/ simply substituted for /t/ in these inflections, or did the increased lenition of /t/ in these environments influence the popular perception of underlying forms and also Zannoni's spelling? The former seems unlikely, given that Italy was approximately 75% illiterate in 1861 and 50% illiterate at the turn of the century (Lepschy and Lepschy 1977: 34-35). In any event, it is uninteresting, as the /t/-[h] alternation would simply be a /k/-[h] alternation. The second explanation – that one phoneme was suddenly substituted for another – is not accepted by Giannelli and Savoia (1991), but is claimed by Izzo (1972: 3). Izzo asserts that "Not later than the beginning of the nineteenth century the intervocalic /t/ of certain verbal morphemes was replaced by /k/ in popular Florentine." Again, the result of an abrupt substitution of /k/ for /t/ also results in an actual /k/-[h] alternation, and would therefore pose no conflict with the idea that the voiceless velar is more prone to *Gorgia* effects. The third possibility is that /t/ simply began leniting to the same extent as /k/ at some point prior to the beginning of the 18th century, in which case we are forced to address the issue of radical /t/ lenition as a very real counterexample to observations that velars are most susceptible to *Gorgia* effects. Since /t/-[h] alternations occur in restricted environments, however, it is quite impossible to place the /t/-[h] alternation in the same post-lexical category as *Gorgia Toscana*, despite superficial similarities.

It appears, then, that either /k/ was substituted for /t/ in certain environments or that /t/ began leniting to the same extent as /k/ in the early part of the 19th century. If the first is true, we can avail ourselves of Labov's (1994) distinction between a "regular sound change" that is gradual, phonetically-conditioned, and free of lexical constraints and a "lexical diffusion change" that is caused by abrupt substitutions of one phoneme for another (1994: 542). Then the /t/-[h] alternations would be a result of "normal *Gorgia* rules affecting the velar" (Hajek 1983: 4). If, on the other hand, radical /t/ lenition occurred in the absence of phoneme substitution, it is clearly conditioned by lexical and morphological factors in a way that other *Gorgia* effects are not. In either case, we can soundly categorize the /t/-[h] alternation separately from regular *Gorgia Toscana* alternations.

1.3.3 Early history of Gorgia Toscana

It is possible the *Gorgia* existed in Dante's time (late 13th/early 14th centuries, or even prior to that period. No definite accounts, however, exist of the process until approximately 1525 (Izzo 1972: 8), when the Sienese linguist Claudio Tolomei published the *Polito*, in which he asserts the "aspiration" of /k/ and /g/ and only of those two segments. According to Izzo, Tolomei's account of spirantization is ambiguous, since his descriptions are limited to "aspiration," and not to fricativization or spirantization. It wasn't until somewhat later in the 16th century (1569) that a more specific description of Italian pronunciation was published by the Welsh grammarian Siôn Dafydd Rhys. Rhys explicitly describes the pronunciation of /k/ in intervocalic contexts as "exactly like German *ch* and Greek χ" (Izzo 1972: 20), and the pronunciation of /p/ and /t/ as full occlusives. At a slightly later point in time, Giorgio Bartoli corroborates these pronunciations in his *Elementi del parlar toscano* (1584). Other references to these pronunciations are found in the 16th century literature, but Izzo notes that the earliest appearances of the term *Gorgia* occur somewhat later, first in Kaspar Schoppe's *Grammatica Philosophica* (1628) and subsequently in Matthias Kramer's *Nuovo Dittionario Reale Italiano-Tedesco* (1693). This provenance of the descriptor *Gorgia* seems to unequivocally refer to the guttural pronunciation of voiceless (and sometimes voiced) velar stops only, particularly in the publication of Girolamo Gigli (*Vocabolario cateriniano*, 1717), although more recently the term *Gorgia* has been extended (somewhat illogically) to describe the spirantization of all three intervocalic voiceless stops (Izzo 1972: 3).

It isn't until Girolamo Rosasco's *Della lingua toscana*, published in 1777, that Izzo notes a reference (vague, at best) to the spirantization of intervocalic /p/ and /t/, an observation that is clearly documented a century later in an anonymous publication *Della pronunzia fiorentina* (1870), which also includes observations on the weakening of intervocalic voiced stops. The description in this work, quoted in Izzo (1972: 46) of lenited /p/ is "the air escapes from the lips, which approach one another and do not touch one another completely...; therefore, there is not a plosive point"[12] and of lenited /t/ is "a light puff passes between the tongue and the incisors."[13] Specific references to /p/ and /t/ lenition are also found in Schuhardt (1884) (cited in Izzo 1972: 55), and attest to the more frequent weakening of the dental than of the labial.

Descriptions of *Gorgia* as affecting velars to a greater extent (or in some cases only) become much more widespread in the literature of the past two centuries, and are corroborated by Izzo's more contemporary observations, which indicate "that the [geographical] area in which /p/ and /t/ are spirantized is much smaller than the area in which /k/ is spirantized or elided" (1972: 98). Synchronic descriptions in recent works by Giannelli and Savoia (1978-79), Marotta (2001, 2003) and Sorianello (2001, 2003) confirm both Izzo's testimony as well as historically documented asymmetrical patterns.

Although the term *Gorgia*, either in the context of *Gorgia fiorentina* or *Gorgia Toscana*, has historically pejorative connotations, the actual surface pronunciation of spirants/fricatives in Tuscan dialects does not appear to mark a low social status. Cravens (2000: 13) notes that "In Tuscany where spirantization is typical of the capital, Florence, the spirants also carry high status...again there is no negative judgment conferred on their use," and Izzo (1972: 100) observed that spirantization, particularly of /k/, occurs in the speech of university students, professors, physicians, and various other professional/business people. Despite the rather prejudicial provenance of the

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[12] *p lene.* – L'aria esce tra le labbra che s'avvicinano e non giungono a toccarsi totalmente in tutta la loro estensione; quindi non c'e' punta esplosione.

[13] *t lene.* – Un lieve soffio passa tra la lingua a gl'incisivi.

term *Gorgia*, it appears that such a term has been widely adopted by linguists as the conventional descriptor of Tuscan intervocalic lenition, and it will be used in the following sections elaborating on the process and elsewhere throughout this paper. Furthermore, seeing no clear reason to view the lenition processes affecting voiceless and voiced segments as distinct, the terms *Gorgia Toscana*, weakening, and lenition will be used interchangeably despite Hajek's (1983: 2) admonition that *Gorgia Toscana* refers only to the spirantization of voiceless stops /p/, /t/, and /k/.

1.3.4 Environmental factors

The fricativization effects of *Gorgia* occur intervocalically, either word-internally or across words, even when such words are not structurally adjacent as in cases of *PRO* and *wh*-traces (Nespor and Vogel 1986, Rizzi 1979, Vanelli 1979). Example 1-5 illustrates these favorable environments.

Example 1-5.
Prosodic effects on *Gorgia*

a. *word-internal*

poco	[poko]	→ [poxo]	‘a little’

b. *word-boundary*

la casa	[lakaza]	→ [laxaza]	‘the house’

c. *across PRO*
Ho visto un passero pennuto e uno PRO [h]alvo. (< uno‿[k]alvo)
‘I saw a feathered sparrow and a bald one.’
(Nespor and Vogel 1986: 51)

d. *across wh-trace*
Chi hai fotografato t_{wh} [h]ol pappagallo sulla spalla? (< fotografato‿ [k]ol)
‘Who did you take a picture of with the parrot on his shoulder?’
(Nespor and Vogel 1986: 53)

Further, although the canonical instantiations of *Gorgia* involve VCV sequences, the final vocalic segment in the sequence may be preceded by a non-nasal sonorant as the tokens in Example 1-6 from Giannelli and Savoia suggest.

Example 1-6.
Weakening of consonants in VCCV contexts
(Giannelli and Savoia 1978)

a. bicicletta	[bitʃiˈklɛtːɑ]	→ [bitʃiˈxlɛtːɑ]	‘bicycle’
b. la trave	[laˈtrɑve]	→ [laˈθrɑve]	‘the beam’

1.3.5 Prosodic restrictions on Gorgia

There are some restrictions on *Gorgia*: Nespor and Vogel provide evidence that *Gorgia* is a Sandhi rule restricted to the domain of the intonational phrase, although they note that in some dialects *Gorgia* may occur within the domain of the utterance.

Example 1-7 illustrates the effects of this prosodic structure on *Gorgia*.

Example 1-7.
Intonational phrase constraints on *Gorgia*
(Nespor and Vogel 1986:206)

a. [$_I$ Certe tartarughe]$_I$ [$_I$ [k]ome si sa]$_I$ [$_I$ vivono fino a duecento anni]$_I$
[$_I$ Certe tartarughe]$_I$ [$_I$ *[x]ome si sa]$_I$ [$_I$ vivono fino a duecento anni]$_I$
'Certain turtles, as you know, live up to two hundred years.'

b. [$_I$ Almerico]$_I$ [$_I$ [kw]ando dorme solo]$_I$ [$_I$ [k]ade spesso dall'amaca]$_I$
[$_I$ Almerico]$_I$ [$_I$ *[xw]ando dorme solo]$_I$ [$_I$ *[x]ade spesso dall'amaca]$_I$
'Almerico, when he sleeps alone, often falls out of the hammock.'

Length of the string appears to be yet another factor in the accommodation of *Gorgia*. Nespor and Vogel (1986: 43) note that *Gorgia* does not occur in the cases in Example 1-8, where it appears be blocked between two phrasal nodes (NP and VP) where it would normally apply. Closer examination reveals that the real obstacle to *Gorgia* in these utterances is the length of the string, possibly related to the existence of an intonational phrase boundary between the lengthy NP subject and following VP.

Example 1-8.
String length effects on *Gorgia*
Nespor and Vogel (1986: 43)

a. [Le zanne dell'elefante bianco dell'Africa orientale]$_{NP}$ [k]ostano sempre di più in Europa.
['The tusks of the white elephant of eastern Africa]$_{NP}$ cost more and more in Europe.'

b. [Quella banda segreta di ragazzi temuta da tutti]$_{NP}$ [k]accia orsi ferocissimi solo per divertirsi.
['That secret band of boys feared by all]$_{NP}$ hunts very ferocious bears just for fun.'

1.3.6 Blocking of Gorgia

Gorgia is also blocked in the across-word environment if the preceding syllable is stressed. In this case, syntactic doubling (Raddoppiamento Sintattico) – gemination of the consonant – occurs. Stress, however, is not mentioned as a conditioning factor in word-internal lenition; nor is there any post-lexical gemination within words, as geminates are contrastive in Italian. The sentences in Example 1-9 show the effects of stress, both across words (a,b) and word-internally (c,d).

Example 1-9.
Stress effects on *Gorgia*

a. ˈtrè [k:]olibrì [b:]rutti (< [k]olibrì [b]rutti)
‘three ugly hummingbirds’
(Nespor and Vogel 1986: 40)

b. ˈquattro [x/h]olline verdissime (< [k]olline)
‘four verdant hills’

c. aˈmi[x]o (< ami[k]o)
‘friend’
(Giannelli and Savoia 1979)

d. amiˈ[x]evole (< ami[k]evole)
‘friendly’

It further appears that even secondary stress on the preceding syllable is sufficient to block *Gorgia*. Note the sentences (b) and (c) in Example 1-10 where, instead of *Gorgia*, Raddoppiamento Sintattico is induced.

Example 1-10.
Secondary stress effects on *Gorgia*

a. la casa	[laˈkaza]	→	[laˈxaza]	'the house'	GT
b. metà casa	[meˈtaˈkaza]	→	[meˈtaˈkːaza]	'half the house'	RS
c. a casa	[ˌaˈkaza]	→	[ˌaˈkːaza]	'(to) home'	RS

With this brief descriptive background of *Gorgia Toscana*, previous formal accounts of the process will be discussed.

1.4 Previous formal accounts of Gorgia Toscana

This section discusses a number of treatments of *Gorgia Toscana* in chronological order, beginning in the latter half of the 20th century when the analysis of Tuscan lenition in contemporary theoretical frameworks began to be carried out. From this evaluation of previous studies, there remain descriptive and explanatory gaps in the literature dealing with *Gorgia Toscana*. The present work is a major step towards filling in those gaps.

1.4.1 Contini 1960

One of the first modern accounts of *Gorgia* is found in Contini's (1960) work "Per un interpretazione della cosi' detta *Gorgia Toscana.*" In it, the author addresses Tuscan lenition as a phonetic phenomenon in which intervocalic stops assimilate to their surrounding vowels – a first attempt at explaining *Gorgia* in terms of coarticulation. Contini, however, tries to account for the geographical restriction of

Gorgia by assuming a regular presence of voiced fricatives in Tuscany, and that such voiced fricatives underwent devoicing in order achieve the more prestigious voiceless pronunciation. The credibility of this hypothesis is unfortunately undermined by Hajek's observation that there was no regular presence of voiced fricatives throughout Tuscany (1983). Izzo's thorough historic account of *Gorgia Toscana* also does not corroborate the basis of Contini's explanation.

What Contini does bring to the table, however, is one of the first analyses of *Gorgia Toscana* as a phonetically motivated process as well as an attempt (even if misguided) to explain the geographical distribution of the process. Contini's early paper is by no means complete, but it introduced questions regarding sound change motivations and constraints that were previously absent from the literature.

1.4.2 Izzo 1972

One of Izzo's well-known contributions is his logical rebuttal of the theory that *Gorgia Toscana* is simply a carryover of Etruscan pronunciation.

At the beginning of the 19^{th} century, the spirantization of voiceless stops in Tuscan dialects began to be attributed to Etruscan influences (Hajek 1983). Supporters of the "substratum hypothesis," as this theory is known, rely on either one or both of the following assumptions:

> “the ‘common sense’ assumption that no language ever succumbs without influencing strongly the pronunciation of the language that succeeds it [and]
>
> the ‘substratomaniac’ assumption that all phonetic changes, or at least all changes that cannot be definitely proven to have had some other cause, are the result of substratum influence.” (Izzo 1972: 114)

Early substratists used geographical, lexical, orthographic, and phonological arguments to support their hypothesis and Izzo does an excellent job in systematically attacking and refuting all such arguments. His work, therefore, not only serves as a thorough review of historical accounts of *Gorgia Toscana* and a report of synchronic lenition throughout Tuscany, but also as the first major rebuttal of the Etruscan substrate hypothesis. In this sense, Izzo can be considered something of a pioneer in the modern treatment of *Gorgia Toscana*.

Despite his contributions to the literature, however, Izzo’s account has serious limitations.

(1) His synchronic account of *Gorgia* constitutes a very small percentage of his overall work and is driven by the desire to address certain specific arguments used by substratists, therefore ignoring many phonetic, phonological, and social factors.

(2) Izzo relies solely on his own qualitative assessments of lenition without incorporating acoustic analysis – not surprising given that Izzo’s fieldwork was carried out in the 1960s.

(3) He devotes a mere paragraph to a “possible non-Etruscan explanation of the *Gorgia*” (Izzo 1972: 175), in which he describes lenition in Tuscan dialects as simply

“the result of weakening of the articulation of occlusives” (1972:175).

Izzo’s work, therefore, is an excellent foundation for further inquiry into *Gorgia Toscana*, but leaves many questions unanswered.

1.4.3 Giannelli and Savoia 1978-80

Giannelli and Savoia (1978, 1979-80) offer the first thorough synchronic account of *Gorgia*, detailing the variant production of all phonemes subject to weakening and positing a number of specific phonological rules to account for varied output given factors of geography, social status, speech rate, focus, casualness, age, gender, emotion, and register. They collected speech samples in the field and incorporated spectrogram analysis in determinating allophonic variants. Concentrating heavily on describing these variants in the dialects of Tuscany, the authors note extreme variability in production along a continuum based on the phonetic parameters of aperture, voicing, and tenseness (1978: 27) with something less than the complete occlusives [p], [t], and [k] occurring at the strongest end of the scale: “a certain presence of [minimally-constricted] [ɸ θ x], whether in strong or weak position, pre-exists Florentine spirantization” (1978:50). For these authors, then, there seems to be a distinction made between “Florentine spirantization” and “general spirantization” (1978: 26) – not the first time in which we will see *Gorgia Toscana* essentially treated as a specific lenition process instead of being analyzed along more general lines.

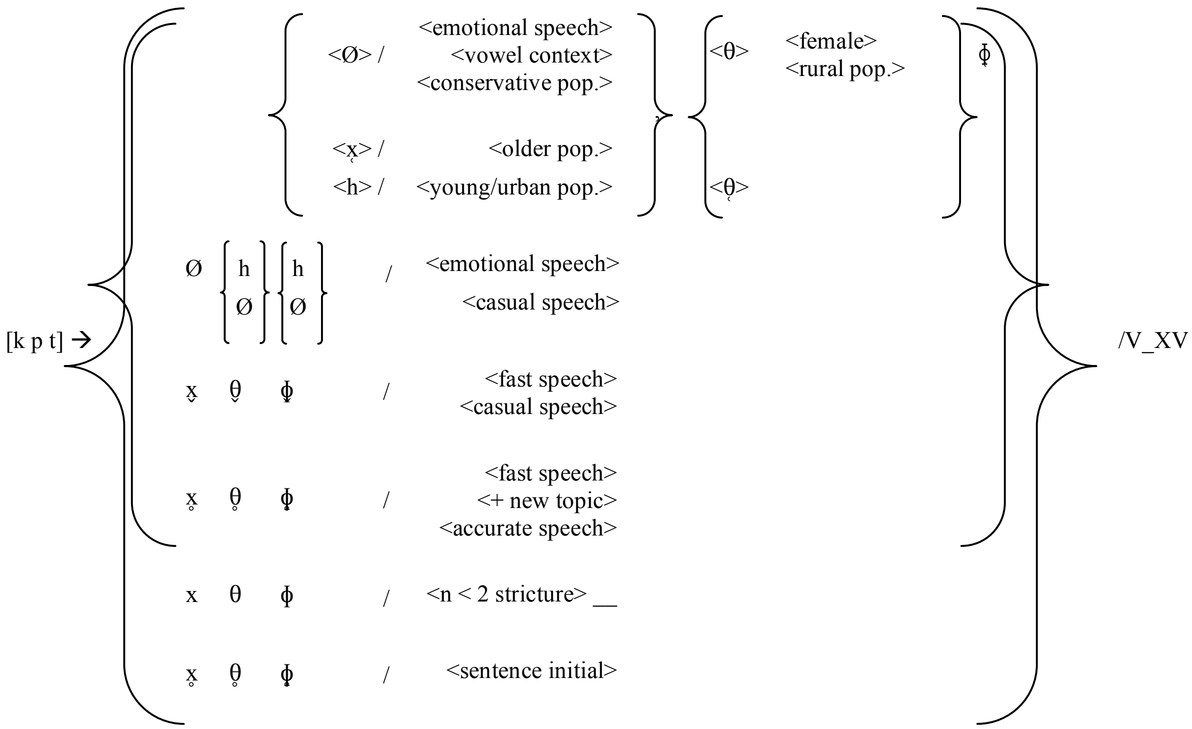
The fine granularity with which Giannelli and Savoia treat lenition and the careful attention paid to stylistics and demographics is manifested in their feature matrix of 31 allophone categories as well as in a number of generative categorical feature-based alternations. Table 1-5 (feature matrix for velar allophones) and Figure 1-3 (recreation of G&S's 'Regola 8') illustrate this.

Table 1-5.
Feature Matrix for Velar Allophones
(Giannelli and Savoia 1978:55) [14]

	k	k̬	x̥	x̜	x̬	k̩	g	ɣ̥	ɣ	h̜	ɦ
Vocalic	-	-	-	-	-	-	-	-	-	-	-
Sonorous	-	-	-	-	-	-	-	-	-	-	-
Consonantal	+	+	+	+	+	+	+	+	+	+	+
Stricture	2	2	1	0	1	2	2	1	0	0	0
Coronal	-	-	-	-	-	-	-	-	-	-	-
Anterior	-	-	-	-	-	-	-	-	-	-	-
High	+	+	+	+	+	+	+	+	+	-	-
Low	-	-	-	-	-	-	-	-	-	+	+
Posterior	+	+	+	+	+	+	+	+	+	-	-
Distributed	+	+	+	+	+	+	+	+	+	-	-
Strident	+	-	-	-	-	-	-	-	-	-	-
Tense	+	+	+	+	+	-	-	-	-	+	-
Voiced	-	+	-	-	+	-	+	+	+	-	+
Long	-	-	-	-	-	-	-	-	-	-	-

[14] G&S's diacritics used to represent maximum and minimum grades of constriction have been altered to [̜] and [̥], respectively due to available symbols in the IPA font inventories. The symbol [̬] is used by G&S to indicate increased voicing on normally voiceless segments.

Figure 1-3.
Weakening Rule 8
(Giannelli and Savoia 1978:43)[15]



These authors' treatment of lenition includes a number of interesting observations. The note that weakening appears to be more extreme when flanking vowels are similar with respect to height, backness, and tenseness, or when the second V is [+back]. Weakening is also frequently found in voiced stops, affricates, liquids, nasals, and geminates (as mentioned above). Additionally, weakening may occur in sentence initial position. Giannelli and Savoia, particularly in their 1979-80 article, also address the development of *Gorgia Toscana* throughout the region of Tuscany, noting

[15] See above footnote on transcriptions.

that Florence has been (and continues to be) the focal point of innovative sound changes related to lenition.

Despite the descriptive breadth of Giannelli and Savoia's pioneering work, there are a few noteworthy limits to their study.

(1) The authors offer no details on their subjects or elicitation methodology, making the study impossible to replicate or evaluate.

(2) They admit that their focus is primarily a descriptive geographic analysis of voiceless weakening, so intrinsic physiological and extrinsic social factors are given secondary attention, at best.

(3) The level of detail the authors adopt in allophonic description includes at nine variants of /p/, nine of /t/ and eleven of /k/ (G&S 1978: 28, 54-55 – see Sorianello (2001: 63) for a concise summary), depending on fine differences in voicing, tenseness, and degree of constriction. Although they mention the use of "spectrogram reading" in their endnotes (1978: 53), it is difficult to conceive that spectrogram data on its own would be sufficient support of such a fine granularity, and the authors do not include spectrograms or otherwise document their method of analyzing them in the body of their work.

(4) The extensive variability in factors contributing to *Gorgia* (sociolinguistic factors such as educational level, gender, age, social

class, speech style, and discourse domains), combined with the granularity of surface manifestations mentioned above, make it difficult to construct a single unified rule or representation describing the process of lenition. Hence we are left with the complicated device put forth in Figure 1-3, which is merely one example of the more than 20 rules offered as descriptions of Tuscan weakening.

(5) Although Giannelli and Savoia point out on numerous occasions the tendency for velars to weaken more than non-velars, generative accounts like Figure 1-3 above do not explain the place-related asymmetry in lenition discussed in Section 1.3.2 without further modification, not supplied by the authors.

(6) Giannelli and Savoia provide only a descriptive account of lenition, but do not attempt or offer explanations as to why it occurs.

1.4.4 Cravens 1984

Rather than a full account of *Gorgia Toscana*, Cravens makes use of general diachronic and synchronic weakening observations in Tuscan dialects in assessing the strength of Foley's (1977) *inertial development principle* (IDP). The IDP states that "weak elements weaken first and most extensively and preferentially in weak environments" (Foley 1977: 107). Cravens points out that the predictions made by the

IDP conflict with Tuscan data, in which /k/ weakens to [h] more often and more regularly than /g/ weakens to [ɣ]. The conflict arises because, according to the implicational parameters inherent in Foley's IDP, /g/ is universally weaker than /k/, and so the former is predicted to weaken more often, given that both /g/ and /k/ lie along the same implicational domain.

Cravens succeeds in eliminating the conflict between the IDP's predictions and actual Tuscan lenition data by incorporating phonetic information into Foley's theory, thus correcting *Foley's paradox* "phonetic considerations at any level are banned from the theory, but the theory cannot function without phonetic considerations" (Cravens 1985). Rather than adopt the Foleyan abstract notion of "strength" or "weakness," Cravens defines these notions phonetically in terms of degrees of occlusion and presence of voicing. In doing so, he argues that the /k/-[h] and /g/-[ɣ] alternations occur along separate implicational domains and are therefore distinct. In other words, according to Foley, these alternations would lie along the same implicational weakening parameter, as in Figure 1-4, making preferential weakening of /k/, a stronger segment, a violation of the IDP.

Figure 1-4.
Single implicational weakening parameter

strongest k >> g >> ɣ >> h >> ∅ weakest

Cravens, however, notes that "Tuscan spirantization of /p t k/, however, at no time results in a realization which could be construed as a shift on the voicing parameter"

(1984: 301). Therefore, two separate implicational weakening parameters are posited for /k/ and /g/. Since the segments now lie on independent weakening scales as in Figure 1-5, Cravens claims the modified IDP is not violated by Tuscan lenition data.

Figure 1-5.
Dual implicational weakening parameter

strongest k >> x >> h >> ∅ weakest

strongest g >> ɣ >> w >> ∅ weakest

Cravens' work is an important step in analyzing Tuscan lenition within an existing theoretical framework, and in acknowledging the importance of phonetic information in the weakening process. He clearly recognizes the need for theoretical frameworks to exceed phonological descriptions of *what a speaker does*, and to address questions of *how/why the change arose* and *how/why it became accepted and spread* (Cravens 1984: 306).

The work, however, is incomplete in some ways:

(1) Cravens' exclusive use of historical lenition data that includes the limited surface variants [h] << [x] << /k/ and [ɣ] << /g/ excludes the consideration of voicing, approximantization, and deletion from his analysis.

(2) He assumes that /g/ is subject to less change than /k/, again based on second-hand (at best) historical accounts, not actual data.

(3) He asserts that [h] (from /k/) is a "rule-governed allophone," while [ɣ] (from /g/) is a "fast speech variant" (1984: 279). This is an excellent example of the traditional treatment of *Gorgia Toscana* as an process limited to spirantization of voiceless stops, and therefore distinct from lenition in general.

(4) Because his immediate goal is the improvement of an existing theory in light of existing data, Cravens essentially ignores the lenition patterns of non-velar segments.

(5) The author acknowledges the importance of explaining the actuation and spread of a sound change, but does not actually address these issues in the context of Tuscan lenition.

1.4.5 Nespor and Vogel 1986

Again we see the application of *Gorgia Toscana* data in a theoretical inquiry not in itself an analysis of Tuscan lenition. Nespor and Vogel's prosodic analysis of *Gorgia Toscana* is exactly that – an inquiry into the constraints exercised by syntactic and positional environments on this process of lenition. The streamlined formalization in Figure 1-6 is the result of their analysis.

Figure 1-6.
Prosodic rule for *Gorgia Toscana*
Nespor and Vogel (1986: 207)

$$\begin{bmatrix}\text{-cont} \\ \text{-voi} \\ \text{-delayed release}\end{bmatrix} \rightarrow [\text{+cont}] \;/\; [_{I}\ldots[\text{-cons}] \_\_ \; [\text{-cons}]\ldots]_{I}$$

These authors offer not only a concise explanation of the effects of prosodic structure on *Gorgia*, but include numerous examples and glosses in illustrating such effects. However, their goals are prosodically-oriented and thus limited:

(1) No insight is offered into the variability of *Gorgia Toscana.*

(2) Place of articulation effects are ignored.

(3) Phonetic data is absent from the analysis.

<u>*1.4.6 Bafile 1997*</u>

Bafile's analysis of weakening in Tuscan dialects is phonological in nature. Thus she eliminates the fine phonetic detail present in Giannelli and Savoia's 1978 account. Her area of inquiry is confined, describing a limited set of surface variants in terms of monovalent *elements* indicating noise, occlusivity, and place of articulation (or absence thereof). The variants of /k/, for example, are defined according to which elements are present or absent, where **h** indicates aperiodic noise present in fricatives and plosives; **@** velar place of articulation (actually the absence of place of articulation); and **ʔ** occlusivity.

Figure 1-7.
/k/ surface variants and associated elements
(Bafile 1997)

[k]	[x]	[h]	Ø
h	h	h	
@	@		
ʔ			

While Bafile succeeds in identifying the phonetically-based features associated with each surface variant, her work has the following major limitations:

(1) The analysis is highly abstract in nature – no phonetic data is analyzed.

(2) It is primarily descriptive in nature and suffers from the same lack of explanatory power with respect to sound change actuation and spread observed in Cravens (1984).

(3) It offers no insight into the variability of *Gorgia Toscana*.

1.4.7 Kirchner 1998, 2001, 2004

Kirchner's work appears to be the first serious attempt to explain the weakening of consonants observed in Tuscan dialects in an articulatory framework. His optimality-theoretic approach to lenition analyzes spirantization as a ranking of the constraint LAZY over constraints on input preservation (such as specification of [-continuant] (1998, 2004).

Kirchner describes lenition as tied to articulatory effort, with effort being affected by factors of speech rate, register, and openness of flanking segments. He offers a detailed ranking system, assigning effort values to consonant allophones across eleven effort levels. Table 1-6 is an excerpt from his effort value table for consonants in weak position, showing the segments and rankings relevant to the present discussion. Note that Kirchner's effort values are based on an arbitrary scale as his arguments are based on relative, not absolute, values of articulatory effort. Note also that at any given level (A-K), all places of articulation are assigned the same effort value.

Table 1-6.
Effort Values for Allophones in Weak Position
Kirchner (1998: 271)

	A	B	C	D	E	F	G	H	I	J	K
p t k	85	89	94	98	103	108	114	120	126	132	138
ɸ θ x	70	74	77	81	85	89	94	98	103	109	114

Lower effort cost/more effort ⟵⟶ Higher effort cost/less effort

The columns A-K in Table 1-6 correspond to rate and register levels, with A corresponding to the slowest rate, highest level of formality, and therefore greatest effort. Each level above A is five percent greater than the preceding level. The values in the table correspond to the relative effort costs associated with the allophones in the far left column – the lower the number, the lower the *cost* of articulatory effort and therefore the *actual* effort permitted in articulating a given allophone may be greater. The fricative counterparts of /k/, /p/, and /t/, therefore, are lower on the effort-cost scale than the stops – fricatives allowing an effort cost of 70, while stops require a higher effort cost of 85 in the slowest, most formal register. This fact manifests itself in the surface forms permitted by Kirchner's incorporation of the LAZY$_{x}$ constraint in a tableau such as that in Figure 1-8, where the maximum effort cost allowed is 75.

Figure 1-8.
Weak position, level A (p,t,k = 85; ɸ, θ, x = 70)
(Kirchner 1998: 274)

	LAZY$_{75}$	*-strid, +cont, +cons	PRES (cont)
p, t, k – p, t, k	* !		
☞ p, t, k - ɸ, θ, x		*	*

Based on the values in Figure 1-8, given a constraint that effort cost can be no greater than 75 (LAZY$_{75}$), the voiceless stops (with values of 85 at level A) are not permitted to surface because they require higher effort than the maximum effort cost specified.

Kirchner's analysis is insightful, as it makes direct reference to the articulatory gestures used in production of allophones. He thus captures strength and weakness in a phonetically motivated way, positing a credible explanation for the actuation of lenition, and unifying a number of seemingly different lenition processes. It does not, however, clearly distinguish among the three voiceless stops' varying susceptibility to *Gorgia* effects attested in previous studies, without further refinement of the effort table to allow for different effort costs corresponding to different places of articulation. Kirchner does posit a constraint [+/- crisp release] to account for the tendency of the voiced velar stop [-crisp release] to spirantize further than the voiced labial and coronal stops [+crisp release], noting that velar stops are less acoustically distinct from continuants because velars generally have a "noisy release" which is spectrographically manifested as multiple release bursts. Whether crispness of release bursts extends to the voiceless stops as well is not noted. Kirchner's model explains much of the variation in Gorgia Toscana and other lenition data, but there are distinct gaps:

(1) The data used by Kirchner are drawn exclusively from Giannelli and Savoia (1978), the deficiencies of which have been noted above.

(2) The effort values which form the basis of Kirchner's analysis are, although articulatorily motivated, arbitrary in nature and not derived from actual speech data.

(3) Kirchner does not, and cannot without adopting a much finer granularity of effort values, address the previously observed asymmetrical lenition pattern that varies by place of articulation[16].

(4) Kirchner accounts only for synchronic lenition patterns in a variety of contexts, but does not address the historical spread of consonant lenition from velars to non-velars.

(5) The theory proposed by Kirchner categorically eliminates the possibility that geminate segments lenite without concomitantly reducing in length, conflicting with earlier observations by Giannelli and Savoia (1978).

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[16] Although there is no reason why Kirchner's account could not be extended by associating different effort values with different articulators.

1.4.8 Cravens 2000

This work is one of the first in which a Labovian approach to the spread and propagation of linguistic change is applied to *Gorgia Toscana*. Cravens' primary goal is that of explaining variation in the /k/ >> /t/ >> /p/ weakening hierarchy. While this hierarchy is observed in Florence, the Bibbiena dialect in Eastern Tuscany weakens its consonants in the order /p/ >> /k/ >> /t/.

Cravens views his Tuscan data in light of three universal implicational tendencies (Cravens 2000: 4; Hajek 1997: 7):

1. Sound change is selective
2. Hierarchies of susceptibility to change are language specific
3. Hierarchies of implementation are consistent through time in the same language.

He notes that the Florentine/Bibbiena variation in weakening order should contradict the third of these tendencies, but points out that the tendency has predictive power only in phonological terms, failing to take into account the social factors which might subvert its application. The factors relevant to his discussion are the sociolinguistic load on /k/-spirantization and the relative lack of such load on /p/-spirantization, given the labial's low rank in the Florentine weakening hierarchy. He argues that the Bibbiena hierarchy, having promoted /p/ and simultaneously demoted /k/, does not necessarily violate the tendency of consistent implementation – it simply means that at certain points during the spread of a sound change there exist conflicting forces on preferential hierarchies of implementation. The phonological force favoring consistency is confronted with a (possibly antagonistic) social force favoring reordering.

Cravens' more recent work makes important contributions to the literature on Tuscan lenition. First, he reviews the diachronic evolution of consonant weakening in the region. Second, he acknowledges that variation is normal and that actual data, not synchronic abstractions, are necessary ingredients in any inquiries into linguistic variation and change. Third, he brings to light /k/'s status in its spirant realization, as "the stereotypical marker of regional association" (2000: 15), and so moves beyond a purely descriptive account of the velar's likelihood to weaken more than other segments. Finally, he views Tuscan lenition as a sound change in progress and clearly supports the integration of internal and external perspectives in the study of such change.

The study being a relatively narrow inquiry into the variation observed in consonant weakening in two different dialects, it is limited in the following ways:

(1) Cravens discusses only the set of voiceless stops, although a larger set of consonants has been observed to undergo weakening in Tuscan dialects.

(2) The phonetic characteristics of surface variants are ignored.

(3) It does not posit an explanation for the velar /k/'s greater susceptibility to lenition.

1.4.9 Marotta 2001, 2003

Two authors have, more recently, published acoustic studies of *Gorgia Toscana*, primarily with an eye to describing the variety of surface variants resulting from the process.

Marotta (2001) illustrates that Pisan stops, both voiced and voiceless, have a rich variety of manifestations beyond that of spirants. Underlying voiced stops surface as stops, fricatives, and approximants; underlying voiceless stops are observed as stops, semi-fricatives, fricatives, and in the case of /k/, as deleted segments (2001: 55). Her analysis includes qualitative assessment of spectrogram data and measurements of consonant and VOT durations. She also addresses the role of perception and phonological knowledge in the categorization of surface variants.

In 2003, Marotta addresses the explanatory power of Kirchner's 1998 OT model and finds it incapable of accounting for the difference between Pisan and Florentine surface variants of /k/, where the Pisan manifestation is generally [x] and the Florentine is generally [ɦ]. She argues (2003: 18) against Kirchner's single LAZY constraint and proposes that varied rankings of faithfulness and markedness constraints are necessary to explain the Pisan/Florentine difference. The rankings in Figure 1-9 account for fricativization of /k/ to [x] and [ɦ], respectively, where the Florentine variant illustrates a more advanced stage of *Gorgia Toscana* in that dialect.

Figure 1-9.
OT-based spirantization in two dialects[17]
(Marotta 2003: 18)

Pisa: /amiko/ - [amixo]
*C Del, *C[-cont], IDENT (Place) >> *C[PlArt] >> *C[-son], IDENT (Manner)

Florence: /amiko/ - [amiɦo]
*C Del, *C[-cont] >> *C[PlArt] >> *C[-son] (>>IDENT (Place), IDENT (Manner))

Marotta's work is innovative in incorporating quantitative acoustic data of both voiced and voiceless segments into the analysis of *Gorgia Toscana*, but it is somewhat limited in the following respects:

(1) Marotta does not actually measure the acoustic qualities of voicing and intensity, both of which may be relevant to the quantification of lenition.

(2) She elects to categorize surface variants in terms of discrete classes so that instead of lenition being described as a truly gradient process, the number of allophone categories is simply increased.

(3) Her studies do not make explicit reference to having incorporated morphological or lexical controls that may be relevant to sound change.

[17] Marotta's constraints in this ranking are, in order: 1) a consonant in *input* cannot be deleted in *output*; 2) consonants in intervocalic position are not negatively marked with respect to continuancy; 3) a consonant in *output* must maintain the same place of articulation as in *input*; 4) consonants in intervocalic position are not marked for place of articulation; 5) consonants in intervocalic position are not negatively marked with respect to sonority; 6) a consonant in *output* must maintain the same manner of articulation as in *input*.

(4) Other than offering a revision of Kirchner's OT account of *Gorgia Toscana*, the studies are primarily descriptive in nature and do not explain the weakening hierarchy documented by Marotta and previous authors in theoretical terms (either phonetic, phonological, or sociolinguistic).

<u>1.4.10 Sorianello 2001, 2003</u>

Sorianello's detailed acoustic studies support *Gorgia Toscana* as a gradient process, and offer a quantitative basis for determining which underlying stops surface as which type of variant. Again, as with Marotta, Sorianello takes giant step forward from the categorical alternations discussed in earlier works.

In 2001, she analyzes the variants of voiceless stops in Florentine, measuring the acoustic qualities of duration, intensity, and frequency. She expands the number of surface variant categories to eight (Sorianello 2001: 66). These allophones are, in order of strongest to weakest

voiceless stops
unreleased voiceless stops
devoiced voiced stops (such as [b̥])
voiced stops
voiceless fricatives
voiced fricatives
approximants
deleted segments

Sorianello argues for an interpretation of *Gorgia Toscana* as a highly gradient process of progressive consonant reduction that extends far beyond categorical spirantization, in line with Marotta (2001), and proposes a novel phonetic transcription for the representation of allophones. She uses spectral analysis as a major cue to differentiate fricative variants. Sorianello also finds a positive correlation between weakening and backness in place of articulation, such that /k/ weakens most, followed by /t/ and then by /p/. In 2003, she reports similar findings from an analysis of informal dialogues between three young Florentine subjects.[18]

It appears that Sorianello has ventured the farthest of any linguist in her extensive use of acoustic analysis in studying *Gorgia*. Still, her work is lacking in a few respects:

(1) Despite the claim that a weakening continuum exists, Sorianello (like Marotta) chooses to categorize surface variants.

(2) No attempt is made to evaluate the results with reference to a theoretical framework: the primary goal is proving that Tuscan stops exhibit a wider array of surface manifestations than spirants and is inherently descriptive in nature.

(3) Sorianello reports no controls of a morphological or lexical nature.

(4) Only voiceless fricatives and their variants are reported.

[18] Sorianello's reporting of the studies is confusing, as it is unclear whether the studies were truly independent. In her 2001 publication, she reports on data collected from six speakers, forming a dataset of 938 voiceless stop tokens. In 2003, she reports on data collected from only three speakers and a dataset of 500 voiceless stops. Despite the different methodologies, the frequency, duration, and intensity measurements are identical in the two studies.

1.5 Conclusions and the structure of the problem

Lenition in Tuscan and Florentine Italian takes a rich variety of forms and exhibits a number of patterns, calling for scientific study in terms of description, quantification, and explanation. The existing literature addressing Tuscan lenition shows that little has been done to quantify and explain this specific case of weakening. Some or all of the following are missing from previous studies:

(1) Detailed, quantitative, controlled, and replicable phonetic analysis of both voiced and voiceless stops undergoing weakening.

(2) Gradient quantification of lenition consistent with claims that weakening occurs along a continuum.

(3) Incorporation or control of morphological and lexical frequency factors.

(4) Explanation of velar susceptibility to lenition.

(5) A resolution of the conflict between Giannelli and Savoia (1978) and Kirchner (1998, 2004) with respect to geminate lenition.

(6) Plausible explanations of the actuation, spread, and variability of lenition.

The study herein addresses these issues in a unified account, thus taking a step forward in formulating an accurate descriptive and explanatory model of this lenition process in the Florentine dialect.

2 Experimental design, methodology, and measurements

In the first section of this chapter I present the hypotheses that will be tested, based on Chapter 1's review of the literature treating *Gorgia Toscana*. Section 2 describes the experimental design in detail. Section 3 outlines the methods used in analysis of the data's acoustic properties, and Section 4 discusses the quantification of lenition indicators.

2.1 Hypotheses

This study has three specific goals: first, to describe lenition in Florentine Italian in a gradient, quantitative, and controlled manner based on acoustic properties of collected speech data. Second, to apply acoustically derived lenition measurements in testing five hypotheses relevant to the gaps in the existing *Gorgia* literature. Third, to evaluate which theoretical frameworks best account for the data and the outcome of hypothesis testing.

The following hypotheses constitute the core of this experiment and drive the selection of independent variables. They are based on previous research on *Gorgia Toscana* and general lenition processes as discussed in Chapter 1.

H1: Velar consonants will lenite more than labials or dentals.

H2: Consonants in high frequency tokens will lenite more than consonants in low frequency tokens.

H3: Word-internal consonants will lenite more than items at word edges.

H4: Word-internal consonants with stress on the left will lenite more than word-internal items with stress on the right. (In other words, foot-medial consonants will lenite more than foot-initial consonants.)

H5: Consonants flanked by back vowels will lenite more than consonants flanked by front vowels.

H6: Geminate consonants will lenite to long fricatives.

H1 predicts that velars, both voiced and voiceless, are more susceptible to lenition than non-velars. It is well documented that voiceless velar stops are targeted by *Gorgia* more than voiceless labials or dentals. This study tests whether place of articulation is a factor in the weakening of voiced stops as well, and whether there is a robust difference in weakening tendencies between labial and dental stops. The outcome of H1 will serve as one of the bases for assessing articulatory theories of lenition.

H2 predicts that lexical frequency will have a positive impact on lenition. Usage-based models (Bybee, Pierrehumbert) claim that physiologically motivated lenition will occur to a greater extent in high frequency lexical items. To date, no study of *Gorgia Toscana* has taken lexical frequency into account. H2 corrects this oversight, and its confirmation or rejection will have implications for both phonetic and usage-based theories.

H3 predicts that word-internal consonants will lenite more than consonants at word edges. Bybee's (2001) usage-based model predicts that single lexical items are more frequent than two-word phrases, even though both may be stored as lexical units. Therefore the outcome of H3 will test the strength of one aspect of Bybee's theory. It will also test for a phonetic aspect of lenition: if articulatory strengthening has been shown to occur at the edges of prosodic domains (Keating 2003: 120), its converse (articulatory weakening) should happen to segments with domain-internal status. The results of testing this hypothesis will shed further light on usage-based models, again, a theoretical framework absent from previous treatments of *Gorgia.*

H4 addresses the possibility that vowel type is a factor in lenition, a prediction not out of line with articulatory approaches to weakening (Browman and Goldstein 1990, 1992), and an interaction that is attested in previous accounts of *Gorgia*, such as Giannelli and Savoia (1978).

H5 tests whether intervocalic stops lenite differently depending on whether they precede or follow stressed vowels, again lending insight into the effects of prosody on articulatory weakening. In this case the domain of inquiry is the foot, and weakening is expected to occur more in foot-internal environments (Harris 2003: 281).

H6 predicts that geminates are not entirely inalterable. Giannelli and Savoia (1978) observe that geminate voiceless stops may be realized as long fricatives. Kirchner (1998) states that geminates do not weaken without first reducing in length. H6 is motivated by this contradiction.

2.2 Experiment and methodology

2.2.1 Justification for the use of Florentine data

With the goals of this study in mind, any language, or language dialect, exhibiting consonantal weakening might be an appropriate target for data collection and analysis. Florentine Italian was chosen for several reasons.

Florentine is one of the many Tuscan dialects well known to engage the process known as *Gorgia Toscana* over nearly all of its consonants and over a variety of speech registers. In Florence, as in many regions of Tuscany, *Gorgia* is a widespread process, spanning prosodic contexts, age brackets, and social status. Giannelli and Savoia (1978: 27) choose 'to examine the phenomenon of spirantization where it occurs most often, and that is in central Tuscany, specifically in the city and immediate surroundings of Florence...'[19]

The treatment of *Gorgia* in the literature is almost completely limited to Italian-language works (Contini 1960; Giannelli and Savoia 1978-80; Marotta 2001, 2003; Sorianello 2001, 2003), which only recently include detailed acoustic analysis of speech (Marotta, Sorianello). English-language treatments of *Gorgia* are few and include general descriptions (Izzo 1972; Lepschy & Lepschy 1977) or entail specific uses of *Gorgia* data as ingredients in discussing prosody (Nespor & Vogel 1986), hierarchies (Cravens 1997), or articulatory effort (Kirchner 1998). None of these works makes use of acoustic analysis of speech data. In the case of Kirchner, the descriptive work of Giannelli and Savoia (1978) is the sole basis of *Gorgia* data. The time is ripe to introduce an updated, acoustic account of *Gorgia* to the body of literature.

Non-linguistic aspects of Florence also contributed to its selection. Of the nine political provinces[20] into which the region of Tuscany is divided, Florence is by far the

[19] 'esaminare il fenomeno della spirantizzazione la' dove esso trova la sua massima realizzazione, e cioe' nell'area centrale e precisamente nella citta' e nell'immediato circondario di Firenze...'
[20] These are Massa Carrara, Lucca, Pistoia, Livorno, Pisa, Arezzo, Siena, Grosseto, Prato, and Florence.

largest, with a population nearing 1/3 of the total Tuscan population[21]. It is centrally located with respect to the other provinces, (see Figure 2-1), enjoys a healthy tourism economy (the city houses a majority of the world's works of art according to recent UNESCO figures), is viewed positively by both Florentines[22] and other Italians[23], and appears to be the location of more study-abroad programs than any other province in the region.

Figure 2-1.
Geographic location of Florence and other Tuscan provinces

[21] Florence's total population at December 31, 2004 totaled 965,388. The total population of Tuscany at that time was 3,598,269. All other Tuscan provinces had a population below 400,000. Source: ISTAT (Istituto Nazionale di Statistica).
[22] Comune di Firenze Ufficio Comunale di Statistica. February 2005.
[23] Il Sole 24 Ore. December 2003 and 2004.

These facts taken together, can be taken as indications of Florence's status within the greater region of Tuscany (and to some extent, the entire Italian peninsula). Such status, both physical and abstract, should be taken into consideration in the discussions of *Gorgia Toscana* to follow.

2.2.2 Subjects

Data were collected from six native speakers of Florentine Italian. Of these, three are female and three male; ages range between 41 and 69; occupations vary among blue-collar and white-collar; and educational levels achieved range from the fifth grade of elementary school to a master's degree. None of the subjects has ever lived outside of Florence for more than three months. Two of the subjects claim no foreign language ability whatsoever. Of the four subjects who do claim L2 ability, none is a native speaker of any language other than Italian. Complete details on subject information are found in Appendix A.

2.2.3 Recordings

All speech data were recorded in quiet rooms familiar to the subjects using a unidirectional microphone, a USB-Pre hard-disk recorder, a Macintosh laptop computer, and PRAAT phonetics software (Boersma and Weenink 2006).

2.2.4 Tokens and elicitation

The set of 1,380[24] sounds analyzed consists of the following:

- voiceless stops 197 /p/, 232 /t/, 231 /k/
- voiced stops 126 /b/, 126 /d/, 108 /g/
- geminate stops 72 /p/, 108 /t/, 72 /k/, 72 /b/, 18 /d/, 18 /g/

Because it includes sounds other than the voiceless stops normally observed to undergo weakening, this project focuses on lenition in the Florentine dialect in a broader way than studies that only pertain to the voiceless stops involved in Gorgia.

All tokens are embedded between vowels (with the preceding and following vowels varying according to the controls outlined below), and either occur word-medially or word-initially within the prosodic domain of the intonational phrase. Where possible, sentences were based on actual spontaneous speech as recorded in the AVIP[25] corpus in order to maximize the naturalness of the utterance.

Subjects were informed that the researcher was studying Florentine Italian, but given no specific information as to the nature of the project or its focus on *Gorgia*. They were then asked to read a total of 33 sentences, in a different random order for each, repeating each sentence three times. A brief warm-up period consisting of informational questions posed by the researcher preceded the experiment so that

[24] This number does not include the six singleton stops that were discarded from the analysis due to disfluencies on the part of the subjects.

[25] Albano Leoni, F., P.M. Bertinetto, D. Locchi, and M. Refice. 2000. AVIP-Archivio delle varietà di italiano parlato. ftp://ftp.cirass.unina.it/cirass/avip.

recording levels could be adjusted and subjects could acclimate themselves to the presence of recording equipment.

2.2.5 Independent Variables

The following independent variables are controlled in the experiment.

- Phonemic length (singleton, geminate)
- Phonemic voicing (voiceless, voiced)
- Phoneme /p/,/t/,/k/,/b/,/d/,/g/
- Place of articulation (labial, dental, velar)
- Vowel backness of V1 and V2 ([-back], [+back])[26]
- Prosodic environment (word-internal or word-boundary)
- Word-internal stress patterns (preceding stress, following stress)
- Lexical frequency (high or low)[27]

Trees constructed for purposes of selecting appropriate tokens based on clusters of these independent variables are in Appendix B. The tokens selected, along with IPA transcriptions, frequency information (from DeMauro 1993), and English glosses are in Appendix C. The list of sentences to be read in random order by subjects as well as the

[26] The high back vowel /u/ is not used in this study due to the impossibility of finding appropriate tokens where V_1 and V_2 in a V_1CV_2 context are both /u/. A brief analysis of vowel frequency in Italian speech shows that the vowels /i/, /e/, /o/, and /a/ have between 85 and 122 occurrences per 1,000 phonemes, while /u/ has only 18 occurrences per 1,000. In addition, vowel backness tests are run on a subset of the data in order to isolate vowel effects from those of frequency, prosody, and stress.

[27] In order to create the clearest dichotomy between high and low frequency, high frequency was defined for purposes of this project as the top fifth of the DeMauro 1993 corpus of spoken Italian and low frequency as having a frequency count (actual number of occurrences in 500,000) of ≤ 2 and a usage coefficient (range of speech types in which token occurs) of ≤ 3. There are two exceptions with mid-range frequencies and usage coefficients due to the difficulty of finding appropriate tokens for two of the variable sets.

English glosses are in Appendix D. In addition to reading these sentences, subjects were asked to read words in isolation in order to confirm that each sound surfaces as a stop in its strongest form.

2.3 Acoustic analysis

2.3.1 Motivation for acoustic study over an articulatory study

Acoustic studies are by their nature far less intrusive and less costly than articulatory studies (such as electropalatography and electromagnetography). As the data for this study was collected in the field, confining it to recordings of speech proved efficient and very likely made participation in the experiment more appealing to subjects.

Although there are sound reasons for incorporating both acoustic and articulatory analysis – completeness of closure can only be assessed indirectly with acoustic analysis, but directly with articulatory methods and Lavoie (2001: 52) notes that the combination of the two provides a fuller phonetic account of the processes investigated than either method alone – there are two counterarguments for the use of articulatory analysis. First, the segments in the present study do not all qualify for analysis in the form of electropalatography (EPG): Labials, having no linguopalatal contact, and velars with a higher degree of backness due to neighboring back vowels, are excluded from the set of consonants measurable with EPG (Lavoie 2001: 53). Second, while articulatory analysis involves the use of devices that can potentially interfere with articulation, acoustic analysis can capture unhindered casual speech (Zsiga 2002:21).

2.3.2 Criteria used in segmentation and labeling of data

Before discussing the dependent variables, their measurements, and motivations, the matter of segmenting data requires some close attention. All tokens were labeled with reference to both the waveform and spectrogram. Vowels were generally defined as periodic sounds exhibiting two or three well-marked resonances and consonants as sounds exhibiting some amount of noise generation (Fry 1979: 111,117). These definitions are relative, as Fry notes (1979: 111):

> From the acoustic point of view, then, there is no sharp line of demarcation between vowel sounds and consonant sounds; there are only sounds which are more like and sounds which are less like the vowels of voiced speech.

In light of Fry's observation, attention was paid to the transitions between vowel-like and consonant-like sounds in VCV sequences.

Following Lavoie (2001: 70)'s review of F2 onset and offset as reliable determiners of segments, most of the actual determination of vowel-to-consonant and consonant-to-vowel transitions was made with reference to the change in F2. In cases where F2 was less clear (usually due to the consonant's constriction period exhibiting robust formants), the amplitude of the waveform was also referenced, and transitions were segmented at the boundary crossing in the waveform where intensity most rapidly dropped (from vowel to consonant) or where it increased (from consonant to vowel) during the VCV sequence. For purposes of segmenting VOT, onset of VOT was determined as the point in the waveform preceding any spike in amplitude that followed a closure (or near-closure) period, and VOT offset was determined by referring to both F2 and the onset of a periodic signal.

Some tokens were, in fact, unsegmentable. These were all singleton stops, and accounted for 48 of the 1,020 total cases, or 4.7%. Of these unsegmentables, all but four were deemed to approach deletion – that is, no qualitative analysis of either spectrogram or waveform enabled the researcher to determine and measure a distinct consonantal period during the VCV sequence. The following chapters will discuss this set of tokens in greater detail.

2.3.3 Summary of dependent variables

Several of the methods used by Lewis (2001 and personal communication) and Lavoie (2001: 69-84) in their analyses of lenition were adopted for the present study. In addition to (and independently of) the quantitative analysis, each token was categorized by allophonic category using waveforms and spectrograms. A summary of the variables measured and their relationships to lenition is in Table 2-1. Allophonic categorization methods, explanations of dependent variables used as lenition indicators and a description of calculations are discussed in detail in the sections that follow.

Table 2-1.
Dependent variables as lenition indicators

Dependent variable	Relationship to lenition
Constriction duration	Decreases
Voice onset time (if applicable)	Decreases
Relative periodicity power of constriction	Increases
Relative intensity	Increases
Burst absence rate	Increases

As discussed in Chapter 1, Lewis (2001) outlines five acoustic parameters that may be used to objectively verify and quantify weakening. These indicators are (1) closure duration (shorter closure = more lenition); (2) VOT (shorter VOT = more lenition); (3) percentage of closure voicing (greater percentage of voicing during closure = more lenition); (4) peak intensity (closer intensity of stop to surrounding vowels = more lenition); and (5) conservation of release burst (lack of burst = more lenition). Lavoie (2001) includes increased formant structure and decreased aperiodic energy as indicators of weakening in addition to those adopted by Lewis, but these measurements are not included in the present study. Formant structures were deemed too difficult to gauge in a reliable, objective way, and decreased aperiodic energy is incorporated in the measurement of relative periodicity power.

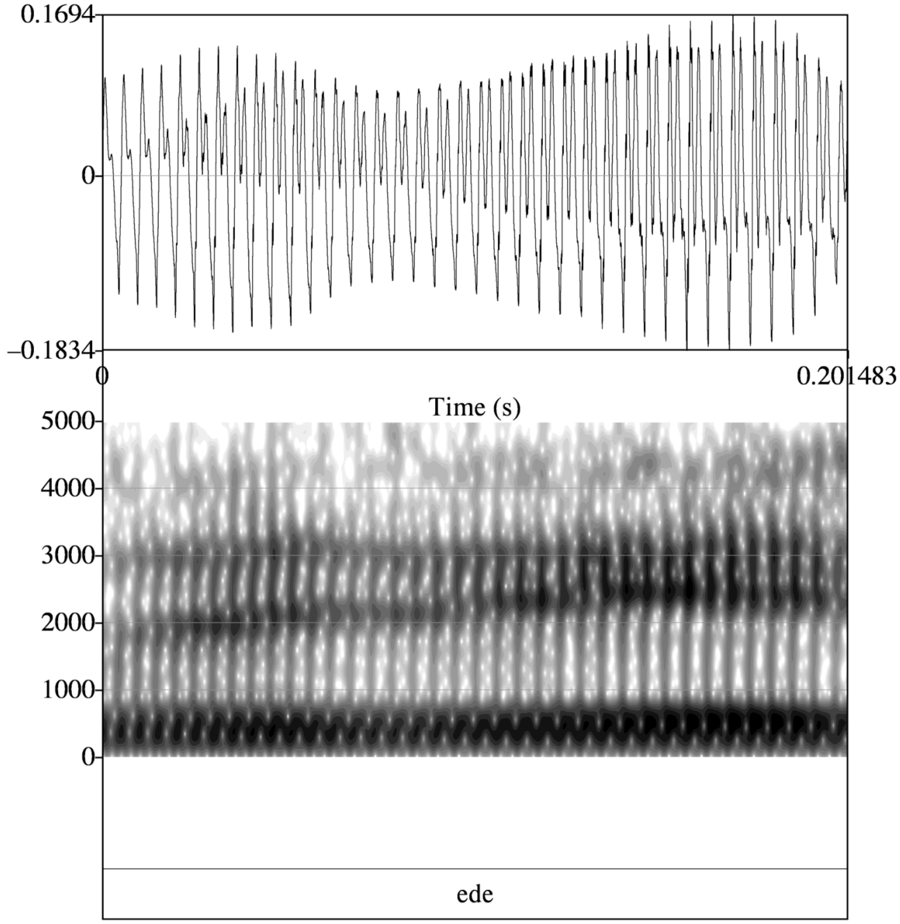
2.3.4 Allophonic categorization

Allophones of the underlying voiced and voiceless stops were placed into one of six categories based on previous experiments by Marotta (2001): weak approximant[28], approximant, fricative, semi-fricative, fricated stop, and stop. Figure 2-2 through Figure 2-7 provide spectrogram examples for each of the categories.

[28] Marotta uses the category 'deleted,' but this study finds weak traces of consonants even in the most extreme cases of lenition. These cases approach deletion, but are conservatively labeled 'weak approximants' throughout this paper.

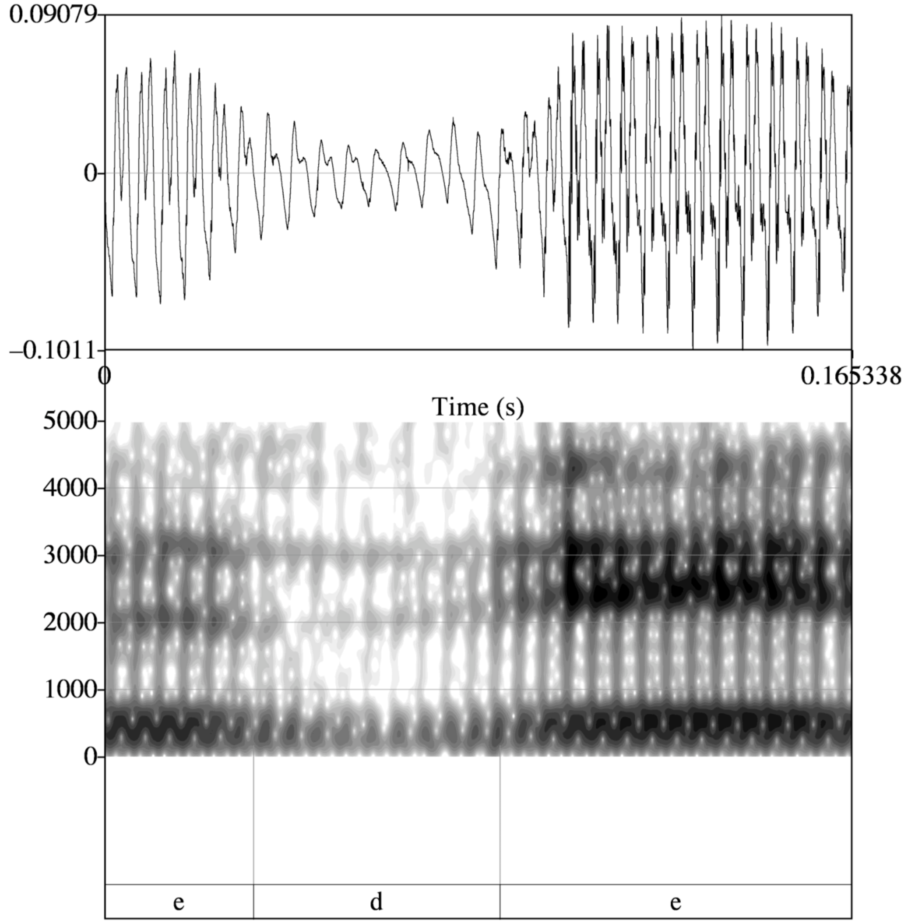
The first category, WEAK APPROXIMANT, identifies those tokens that are unsegmentable and have no clear consonantal qualities between V1 and V2. In this group, as we might expect, formants remain robust throughout the VCV sequence and no large amplitude changes occur where the consonant segment is expected to be (although there is some noticeable amplitude reduction).

Figure 2-2.
Weak approximant
(Subject F1, sentence 2, *vedere* 'to see')



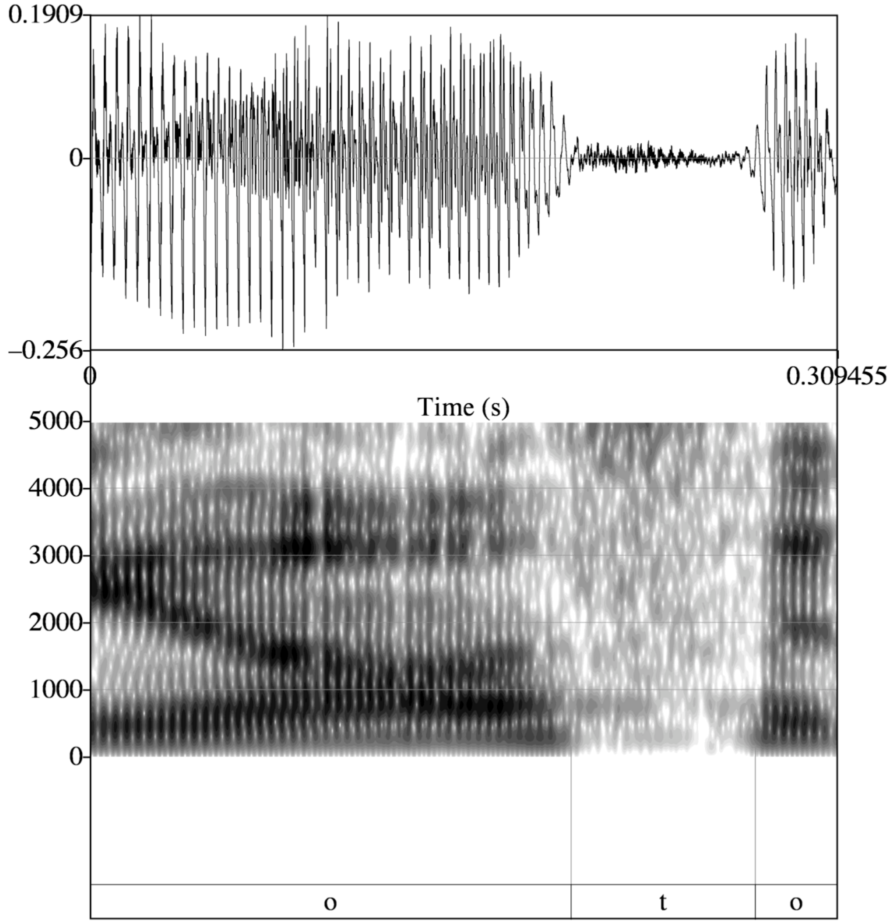
The second category is APPROXIMANT and tokens in this category are generally segmentable. That is, there is a clear indication of a consonantal segment between V1 and V2, although amplitude is relatively high there is a greater reduction than in the case of WEAK APPROXIMANT segments. Release bursts and VOT are absent, formants are strong and vowel-like, and the waveform is greatly simplified.

Figure 2-3.
Approximant
(Subject F1, sentence 2, *vedere* ‘to see’)



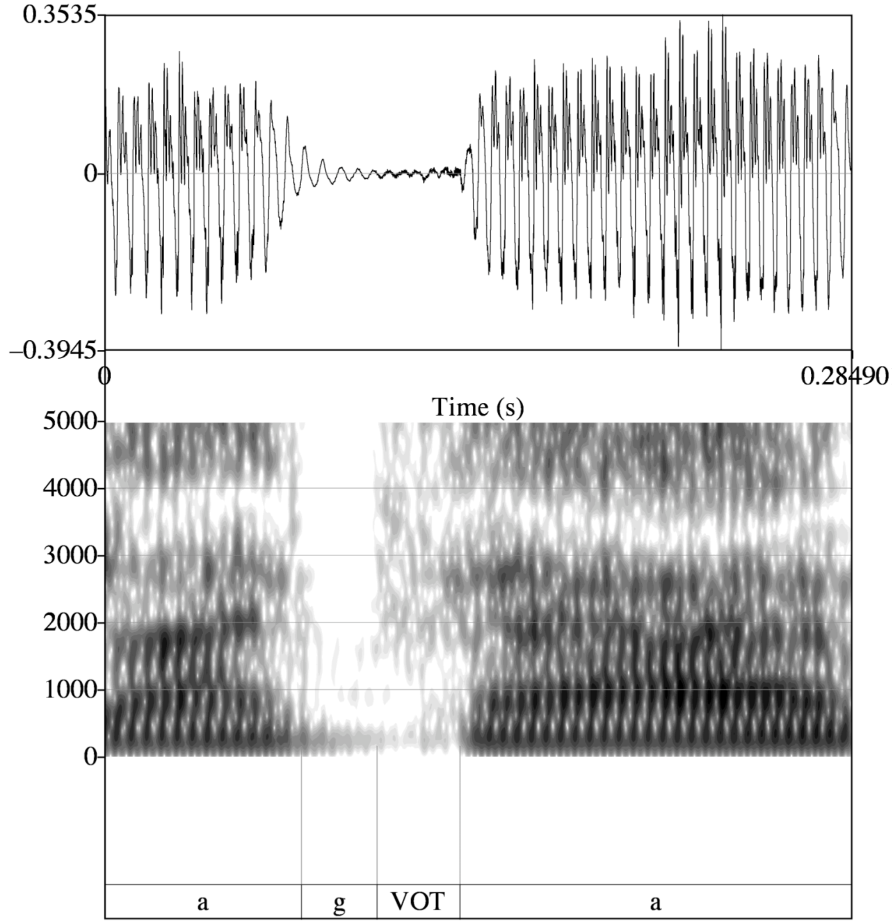
FRICATIVES – tokens with turbulent, aperiodic noise throughout a range of frequencies or with a concentration of power at a specific frequency (Fujimura & Erickson 1997:75) depending on their place of articulation, but without bursts or positive VOT, make up the third group.

Figure 2-4.
Fricative
(Subject F1, sentence 13, *ignoto* ‘unknown’)



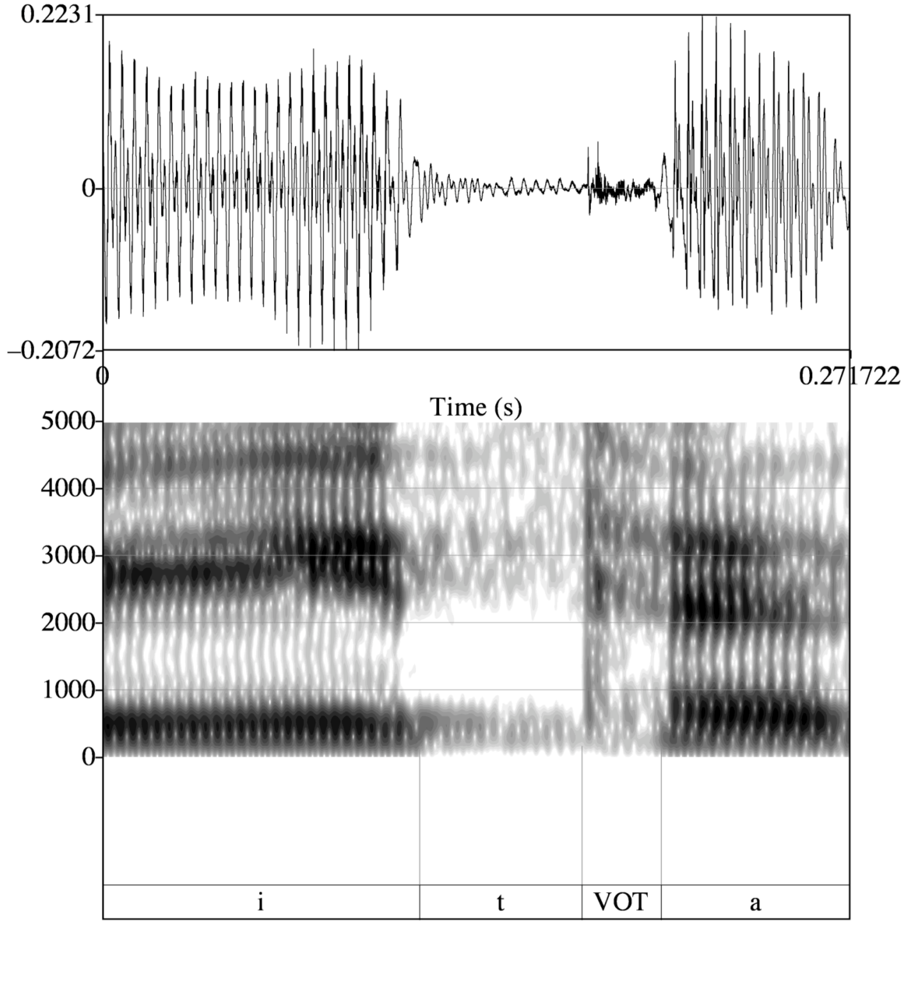
Marotta (2001: 45) discusses the characteristics of SEMI-FRICATIVES (category four). These are those tokens that contain two distinct periods – the first with very low amplitude or waveform activity and a second with diffused noise resembling VOT – and no visible burst between the two. Segments in this category bear a strong resemblance to affricates in Lavoie's (2001) lenition study.

Figure 2-5.
Semi-fricative
(Subject F2, sentence 17, *la gabbia* 'the cage')



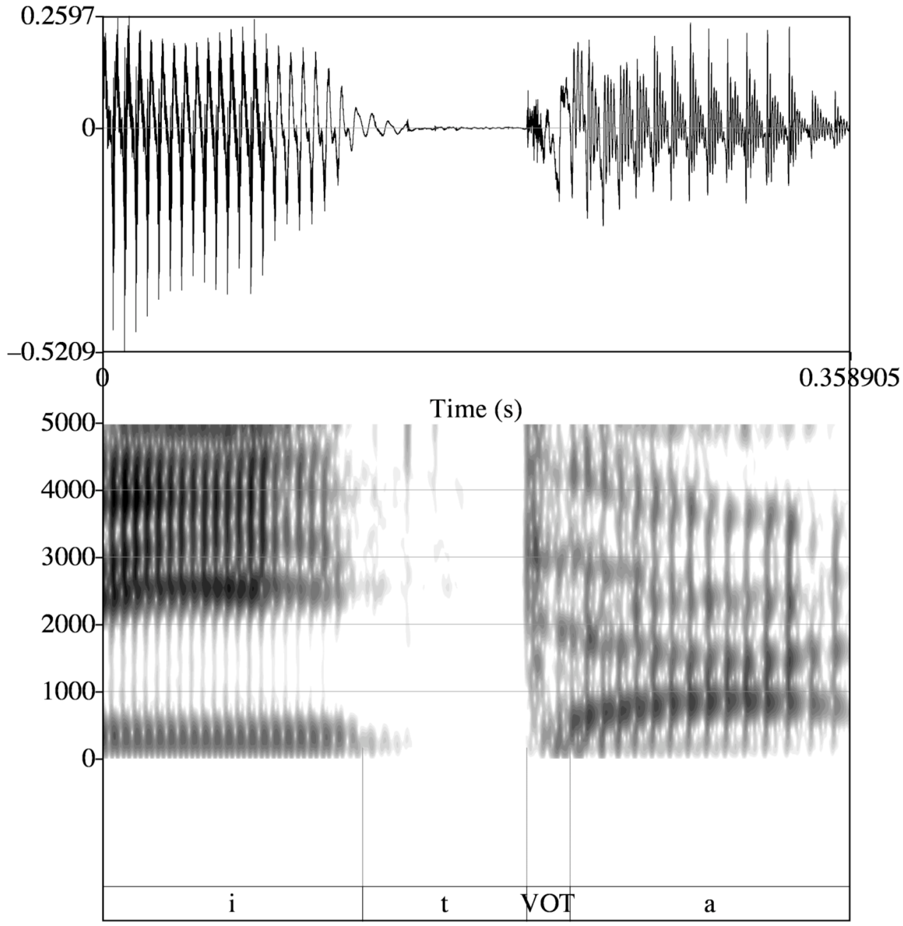
FRICATED STOPS in category five resemble canonical stops in all ways, except that their constriction period contains some diffused noise not generally associated with stop closures – they appear as leaky stops, or stops with incomplete seals, according to Lavoie (2001: 128).

Figure 2-6.
Fricated stop
(Subject F1, sentence 13, *vita* ‘life’)



And finally, STOPS are those tokens surfacing with a period of complete closure – either total silence in the case of voiceless stops or closure with vocal fold vibration in the case of voiced stops (Fujimura & Erickson 1997: 74), a visible burst, and VOT.

Figure 2-7.
Stop
(Subject M3, sentence 13, *vita* 'life')



For ease of interpretation, Table 2-2 summarizes the allophonic categories in terms of a minimal number of features evident in the waveform and/or spectrogram that are necessary to assign a given token to that category.

Table 2-2.
Feature matrix for allophonic categorization

Category	Visible consonant	Clear V-to-C transition	Formants	Diffused Noise	VOT	Release burst
Weak approximant	-	-	+	-	-	-
Approximant	+	+/-	+	-	-	-
Fricative	+	+	-	+	-	-
Semi-fricative	+	+	-	+	+	-
Fricated stop	+	+	-	+	+	+
Stop	+	+	-	-	+	+

An important feature in this analysis is the presence or absence of a release burst. The acoustic cue representing a burst can be described as a "spike," or vertical bar, in the spectrogram following the period of closure or near-closure sufficient to allow increased pressure in the oral cavity necessary to generate a short pressure impulse (Johnson 1997:131). Bursts, by their nature, are detectable in the spectrograms with a high-degree of reliability for all obstruents in this data set, although the duration and intensity of the burst and interval immediately following constriction is variable depending on the place of articulation and voicing of the stop (Olive, Greenwood, Coleman 1992: 81-92). Labials tend to have the shortest VOT durations and velars the longest, dentals the loudest bursts, and velars multiple bursts. Voiced stops and unaspirated voiceless stops have shorter VOT durations than voiceless stops. Olive et al, however, note the great extent of variation even within speakers in burst intensity and VOT duration (1992: 85); this analysis of bursts therefore confines itself to the categorical decision of whether a visible burst is present or absent in the spectrogram of a given token, without regard to its intensity, singularity, or any other feature.

Since the categorization of tokens into allophonic groups is a qualitative, and somewhat subjective task, Chapter 4 addresses the results of this categorization in light of quantitative analysis performed on the data. But first, a thorough discussion of the quantitative measures employed is called for.

2.4 Quantitative indicators of lenition

This section addresses in detail the choice of five quantitative measures, including a description of each, the manner in which measurements were performed on the data, and their relationship to weakening.

2.4.1 Constriction and VOT durations

Constriction duration is measured in absolute terms in this experiment as the duration in milliseconds between offset of the preceding vowel (V1) and either the onset of the following vowel (V2) or the release burst. Because of the inter- and intra-speaker variation in terms of speech rate, absolute constriction duration does not permit comparisons across subjects or tokens. Therefore, a computed variable, Relative Constriction Duration is used, in order to normalize the data and permit such comparisons.

Relative Constriction Duration is calculated as the ratio of constriction duration to total VCV sequence duration. A few examples from the data in Table 2-3 serve to illustrate the necessity of this computation.

Table 2-3.
Absolute versus relative constriction durations

Subject	Sentence	VCV sequence	Sentence duration	VCV duration	Absolute constriction duration (ms)	Relative constriction duration
F1	1	ekɔ	364 ms	338 ms	56 ms	.17
F3	1	ekɔ	251 ms	165 ms	55 ms	.33

These two examples show that for two different subjects speaking the same sentence (*Secondo quella donna, a Viareggio si sta abbastanza bene* 'According to that woman, Viareggio is pretty nice'), rates of speech are markedly different: 364 ms for subject F1 and 251 ms for subject F3 (a faster talker). If we were to use Absolute Constriction Duration as a measurement, the subjects are nearly the same: F1's constriction duration of the /k/ in *secondo* [se.kɔn.do] 'according' is 56 ms, and only very slightly longer than F3's constriction duration of 55 ms of the same segment. But in terms of Relative Constriction Duration, the numbers differ by a factor of almost two: F1's /k/ in the /ekɔ/ sequence constitutes 17% of the total VCV sequence duration, while F3's /k/ is 33% of her VCV sequence. In both cases, the consonants are surfacing as fricatives, but one is significantly shorter than the other. Similar rate effects on Absolute Constriction Durations are seen within subjects as well, making even analysis by individual subject unrealistic if absolute terms are adopted for duration measures.

The same method of calculating Relative VOT Duration as the percent of total VCV sequence spanned by Absolute VOT Duration was adopted, and added to Relative Constriction Duration results in Total Phoneme Duration. Of course it must be noted that in many cases VOT duration is zero.

There are several indications in the literature that weaker segments are shorter in duration than stronger segments. First, the weakening hierarchy in Vennemann (1988) and Hyman (1975: 165) described as a unidirectional progression among varying degrees of weakness, such that "A segment X is said to be weaker than a segment Y if Y goes through an X stage on its way to zero" necessarily implies a negative correlation between consonant duration and weakening, as the weakest category on the scale (deletion) entails a duration of zero. This hierarchy is repeated in Figure 2-8.

Figure 2-8.
Weakening hierarchy
(Vennemann 1988)

-voi stop >> +voi stop >> +/- voi fricative >> approximant >> glottal >> ∅

Recalling that per this same unidirectional progression, voiced stops are weaker than voiceless stops, we should expect to see shorter constriction and VOT durations when consonants exhibit voicing. With respect to constriction duration, Fry (1979: 122) states that the "silence [in plosive consonants] is likely to last something between 70 and 140 ms, being shorter in the voiced sounds than in the voiceless."

Lavoie (2001: 159) reaches the following conclusion with respect to duration as a lenition indicator.

> A major phonetic result of this research is that the main acoustic correlate of lenition is decreased duration. While the usual phonological correlate of lenition is said to be voicing, my data do not uniformly show additional vocal fold vibration in segments, but rather shorter duration. The shorter duration has been shown by other researchers to give rise to the percept of voicing. Additionally, the shorter durations may not provide enough time for speakers to reach articulatory targets, resulting in target undershoot. Shorter segments may also lack sufficient pressure build-up to produce stop bursts.

It is important to note here that the durations of voiced stops are significantly different from the durations of voiceless stops. Any use of duration, therefore, as a measure of lenition, may necessitate independent analysis of consonants based on their phonemic differences in duration.

Manner of articulation is yet another matter. Approximants, being the weakest segments have shorter durations than fricatives, which in turn have shorter durations than stops. Marotta (2001: 32)'s data on lenition of Pisan stops in VCV contexts reports average durations in segments surfacing as stops of 68 ms for /b/, 60 ms for /d/, and 65 ms for /g/, while durations for fricatives are 56 ms for /b/, 48 ms for /d/, and 58 ms for /g/. Approximants have the shortest durations of all: 37 ms, 30 ms, and 39 ms, for /b/, /d/, and /g/, respectively.[29] Sorianello (2001: 75), in a study of lenition in Florentine

[29] It is not clear whether these measurements pertain to constriction duration alone, or the total duration of the segment.

Italian, notes that "Esita una stretta correlazione tra gli allofoni analizzati e la loro durata temporale,"[30] with durations of approximants being the lowest, increasing in voiced fricatives, and increasing further in voiceless fricatives.

A potential problem in using only constriction duration as a lenition indicator, however, becomes apparent when we consider Fry (1979: 137)'s observation that the constriction period in stops lasts anything from about 40 to 120 ms, while the acoustic cue for affricates and fricatives (presumably weaker segments), is "the presence of noise of appreciable duration, from about 70 to 140 ms." Such an overlap of durations indicates a possible positive correlation between constriction duration and lenition, a relationship that is in fact borne out in the present study's data and will be addressed in later chapters.

2.4.2 Relative intensity

Because absolute intensity varies to some extent both within (speakers at times changing their distance from the microphone) and among speakers (some speakers being inherently louder than others) measurements of consonant constriction in deciBels of mean absolute intensity were converted to intensity ratios. This was done by subtracting the mean intensity in dB of the utterance from the mean intensity of the constriction period. The reason Relative Intensity is not calculated by subtracting mean absolute intensity of constriction from mean absolute intensity of the VCV sequence is that open vowels like [ɑ] and [ɔ] generally have intensities 5 dB higher than [i] and [u]

[30] "There exists a tight correlation between the allophones analyzed and their duration."

(Ladefoged 2001: 165). The use of mean utterance intensity therefore removes the potential effect that surrounding vowels might have on relative intensity of the intervening consonant.

Mean Absolute Intensity of constriction and utterance were measured by incorporating the power-in-air algorithm used by PRAAT, which calculates the power of a given sound in air in terms of Watts per meter-squared as

$$power\ (\text{Watt / m}^2) = 1 / (pcT) \int x^2\ (t)\ dt$$

where $x(t)$ is the sound pressure in units of Pa (Pascal), p is the air density (approximately 1.14 kg/m^3), c is the velocity of sound in air (approximately 353 m/s), and T is the duration of the sound (Boersma & Weenink, 2005). The resulting power in air was then converted into dB using the following formula

$$intensity\ (\text{dB}) = 10 * \log10\ (power)$$

and Mean Relative Intensity of the phoneme (constriction period only) was calculated as

$$Mean\ Relative\ Intensity = intensity\ (\text{dB})_{\text{phoneme}} - intensity\ (\text{dB})_{\text{utterance}}$$

As with duration, intensity can be considered as a correlate of weakening – the higher the intensity of a sound, the more vowel-like and less consonantal it is, owing to the negative correlation between intensity and degree of constriction in the vocal tract. Fry (1979: 126) illustrates this generalization in Table 2-4, where relative intensities of each consonant are shown with reference to [θ]. Fry does not explicitly mention whether these intensity measurements incorporate the release burst in the case of stops, but it is presumed they do.

Table 2-4.
Relative intensity of English sounds (in dB)
Fry (1979: 126)

Sound	Intensity (in dB)
o:	29
o	28
a:, ʌ	26
ə:	25
a, u	24
e	23
i, u:, i:	22
w	21
r, j, l	20
ʃ	19
ŋ	18
m	17
tʃ	16
n	15
dʒ, ʒ	13
z, s	12
t, g, k	11
v, ð	10
b, d	8
p, f	7
θ	-

Vowels and vowel-like sounds such as approximants and glides have the highest intensities, while segments that Fry calls "weak fricatives and plosives" appear lowest on the intensity scale. Lavoie (2001: 89) also takes intensity to be a reliable correlate of weakening, given the robust alignment of intensity, sonority, and vowel-likeness, and finds that English and Spanish consonants pattern as expected in terms of their intensity, as illustrated in Table 2-5. Because Lavoie calculated intensity by subtracting the consonants' average RMS amplitude from that of a flanking vowel, negative numbers here represent the highest intensity. Two of Lavoie's tables have been combined into one for ease of comparison.

Table 2-5.
Intensity ratios for English and Spanish segments
(Lavoie 2001:90)

Intensity ratio	English segments	Spanish segments
-1	n	n, ɲ, j
0	l, ɹ, ɾ	m, l
1	m, ð, v, ʒ	
1.8	z	
2	b, d, g, dʒ	ð
2.5	tʃ	
3	θ, ʃ	β, r
4	p, t, k, s, f	ɣ, ɾ
5		v
12		x
13		p, tʃ, s
16		f
17		k

Sorianello (2001)'s treatment of intensity values in Florentine involves a similar method of measuring intensity, although it appears she subtracted maximum vowel intensity from maximum consonant intensity, instead of using means. Sorianello also concludes that increased intensity is a correspondent of weakening. Her results are below in Table 2-6, but note they are on a different scale than Lavoie's data due to the difference in methodology, and that in this case higher values indicate higher intensity. In addition, intensities are given by allophone, as categorized by the author, not by underlying phoneme.

Table 2-6.
Intensity ratios for Florentine allophones
(Sorianello 2001:74)

Intensity ratio	Allophone
-32	ɸ, β
-25	h + V[-front]
-24	ɣ, ɦ + V[-front]
-23	h + V[+front]
-21	ð
-20	β̥
-19	θ
-17	ð̥
-16	ɦ + V[+front]
-10	ɣ̥
-9	θ̥

It needs to be noted here that while overall intensity appears to be a correlate of weakening, intensity of noise (whether in the burst or friction noise) will be greater in voiceless consonants, as "vocal fold vibration uses up a proportion of the energy available for producing a syllable; the less energy used in this way, the more there is to be dissipated in noise generation" (Fry 1979:137). The data in this study, however, are analyzed for overall intensity, not noise intensity, so that higher intensity will generally pattern with higher extent of weakening.

2.4.3 Relative periodicity power

Periodicity was calculated using the "Harmonics to noise ratio" or "harmonicity" of Boersma (1993):

> A Harmonicity object represents the degree of acoustic periodicity, also called Harmonics-to-Noise Ratio (HNR). Harmonicity is expressed in dB: if 99% of the energy of the signal is in the periodic part, and 1% is noise, the HNR is 10*log10(99/1) = 20 dB. A HNR of 0 dB means that there is equal energy in the harmonics and in the noise.[31]

The cross-correlation method, with time step of .01 ms and minimum pitch of 75 Hz (see Boersma 1993), was used.

In order to avoid negative values, the HNR values were de-logged and converted to Relative Periodicity Power as follows:

Relative Periodicity Power (RPP) = 1 / (1 +10^ (-dB/10)

According to Boersma, the RPP values correspond with deciBel values as illustrated in Table 2-7.

[31] Boersma & Weenink (2005)

Table 2-7.
Relative Periodicity Power and its correspondence to HNR in dB

Relative Periodicity Power	HNR in dB	Amount of periodicity
.999999999	90 dB	Almost perfectly periodic
.999999	60 dB	
.999	30 dB	
.91	10 dB	
.50	0 dB	As much harmonic power as noise power
.09	-10dB	

As the table illustrates, a RPP value of .50 (0 dB) translates into equal amounts of periodicity and noise. It is important to note now, and will continue to be important in later chapters, that RPP not be confused with the percentage of the sound's duration that is voiced. While 50% voicing for a segment like /k/ would entail a significant amount of surface voicing, a RPP of .50 for /k/ means that it is effectively not voiced at all.

Voicing patterns similarly with intensity in terms of its correspondence with weakening, at least within certain classes of segments. The Vennemann weakening scale mentioned above indicates that voiced stops and fricatives are weaker than their voiceless counterparts, and that approximants and vowels (almost always voiced) constitute the weakest groups. This is not surprising, given the positive correlation between voicing and intensity – Fry's relative intensity scale shown in Table 2-4 illustrates that voiced segments are generally of higher intensity than voiceless. The correlation is not perfect, however, as the strident fricatives such as [ʃ] and [s] have intensities much higher than the voiced stops and the voiced labiodental fricative [v], leading to the conclusion that overall intensity may be greatly affected by extreme noise.

There is also a correspondence between voicing and duration, although this time it is a negative correlation. Maddieson (1997: 626) reports data from unpublished research on Italian data by Dunn (1993) attesting to voiced /b/ having a shorter duration than voiceless /p/. Measurements for two speakers note average /b/ durations at 76 ms and 86 ms, while average /p/ durations for the same speakers are 99 ms and 118 ms. Sorianello (2001) reports the following weakness hierarchy among Florentine consonants, based on allophonic categorization and measures of duration and intensity. Sorianello does not measure voicing in her experiment, but we note the tendency for weaker segments, which have shorter durations, to be more voiced, and the general correspondence with Vennemann's hierarchy in Figure 2-8 above.

Table 2-8.
Relative weakness of allophones
(Sorianello 2001: 82)

Strongest	voiceless stop
	unreleased voiceless stop
	weakened voiceless stop
	voiced stop
	voiceless fricative with maximum constriction
	voiceless fricative with medium constriction
	voiced fricative
	approximant
Weakest	deleted

Lavoie (2001: 105) also finds that durations are shorter in voiced consonants, although comments that her expectations of voicing as a robust indicator of lenition were not met due to a high amount of speaker variation. Nevertheless, Table 2-9 illustrates her general findings for English and Spanish consonants.

Table 2-9.
Mean durations for English and Spanish segments
(Lavoie 2001:106)

Duration in ms	English segments	Spanish segments
133	tʃ	
121	ʃ	
118	t	
113	s	
108		x
107	p	
103		p, tʃ
102		t
101	f, k	
100	θ	
97		s
92	dʒ	k
89		ɲ, j
82		ŋ
75	r, z	
74	b, g	
72	l	n, r
71	d	
70	m, v	
67		β, ɣ
66		l
64		v
59	ð	

Duration in ms	English segments	Spanish segments
58	n	
56		ð
36	ɾ	
27		ɾ

Looking at the predictive qualities that duration, intensity, and voicing appear to have on consonant weakening, it comes as no surprise that numerous phonetic ingredients are involved in the phonological construct of sonority. More sonorous elements are generally weaker elements per any of the sonority hierarchies presented in Chapter 1. As discussed in the preceding sections, there is good evidence to consider decreased duration and increased intensity and voicing as correlates of weakening. *Res ipso loquitor*; they are correlates of sonority as well.

2.4.4 Release burst absence

Considering the sonority and weakening hierarchies, one notices a clear pattern of less constriction in weaker segments. Since release bursts can only occur when complete closure is attained at some point in the vocal tract for at least 20 to 30 ms, allowing a sufficient buildup of air pressure (Shadle 1997: 48), it follows that only those consonants with a maximal amount of oral constriction (the strongest consonants) will produce bursts. An exception to this general rule occurs when stops occur in either syllable- or word-final position, but is not relevant in this study as all consonant tokens occur in a VCV context.

With this description of the experiment and its variables completed, we move on to a descriptive analysis of the data by allophonic category.

3 DESCRIPTIVE STATISTICS AND HYPOTHESIS TESTING

This chapter discusses in detail the results of descriptive statistics run on the allophones defined in Chapter 2. In addition, it presents the outcomes of hypothesis testing using allophone category as a dependent variable. Although Chapters 4 and 5 will address lenition quantitatively, and as a gradient process, a first look at the data in qualitative terms serves a dual purpose. First, it proves an excellent method for error-checking the database before running further statistics. Second, the results of allophonic analysis provide a preliminary basis for determining which of the several dependent variables, if any, can actually be considered correlates of lenition.

The first and second sections of this chapter detail allophonic variation in terms of several independent variables and present the outcome of hypothesis testing in terms of this qualitative allophone analysis. Section 3 examines how the quantitative measures of duration, intensity, and voicing pattern with allophonic categories. Section 4 compares my results to those of other acoustic studies of lenition, and the final section assesses the reliability of typical indicators of lenition in order to establish a reliable basis for the factor analysis presented in Chapter 4.

3.1 Descriptives: allophonic variation by independent variables

In this section I present the outcome of crosstabulations of a number of independent variables by the six allophonic categories discussed in Chapter 2. The independent variables are: subject, gender, phoneme, voicing, place of articulation, lexical frequency, prosodic domain, stress position, and vowel backness. The categories are, in order of strongest to weakest: stops, fricated stops, semi-fricatives, fricatives, approximants, and weak approximant segments[32]. The analysis is carried out only on singleton segments (since, as we will see, geminate behavior differs significantly from that of singletons). Geminates will be discussed in a separate section. Of a total of 1,026 cases of oral singleton tokens, 6 are excluded because of disfluencies that prohibit accurate measurement of the tokens. The resulting N for the crosstabulations discussed here is constant at 1,020, with one exception: the analysis of allophonic variation by position of stress is only relevant for tokens occurring in word-medial contexts, which number 683.

With this brief background on the tests adopted in this chapter, we move on to actual results.

3.1.1 Allophonic variation by subject and gender

Table 3-1 and Table 3-2 detail each subject's production of the six allophones.

Table 3-1.
Realization of singleton stops by subject (percentages)

Variable	*n*	Allophone						χ^2	*p*	*V*
		Stop	Fric. stop	Semi-fric.	Fric.	Approx.	Wk. approx			
Subject								367.62	<.000	.27
M1	169	--	8%	--	56%	28%	8%			
F1	170	6%	11%	2%	48%	19%	14%			
F2	171	14%	9%	4%	65%	9%	--			
F3	170	32%	5%	5%	46%	11%	2%			
M2	170	31%	19%	5%	32%	11%	2%			
M3	170	58%	18%	1%	21%	2%	--			

Table 3-2.
Realization of singleton stops by subject (numbers)

Variable	n	Allophone						χ^2	p	V
		Stop	Fric. stop	Semi-fric.	Fric.	Approx.	Wk. approx			
Subject								367.62	<.000	.27
M1	169	--	14	--	94	48	13			
F1	170	10	18	3	82	33	24			
F2	171	23	15	6	111	16	--			
F3	170	54	8	8	78	19	3			
M2	170	53	33	8	55	18	3			
M3	170	99	30	1	36	4	--			
Totals	1020	239	118	26	456	138	43			

A significant amount of intersubject effects are observed. Two of the subjects, M1 and F1 can be described as 'heavy' leniters: in fact, none of the 169 oral singleton stops tested for subject M1 surfaced as full stops, and only 14 (8%) of his total contained a release burst. F1 follows close behind with 31 (19%) of her stops realized with release bursts. These two subjects also account for the majority of approximantized and weak approximant segments. Subjects F2 and F3 can be considered 'moderate' leniters. More of their tokens surface as stops, but the percentage of segments surfacing with release bursts is still relatively low: 27% for F2 and 42% for F3. The subjects exhibiting the least amount of lenition are M2 and M3, with the latter being a particularly 'light' leniter. M3's oral singleton stops surface with no variation 58% of the time, and 77% of his stops surface with a burst.

The female subjects generally lenite more than males, although due to the small number of subjects and the observation that M3 is an outlier, it is inappropriate to make any strong claims regarding gender effects on lenition and statistics for this test are not reported.

3.1.2 Allophonic variation by phoneme

Table 3-3 and Table 3-4 show the percentage and number, respectively, of each surface manifestation of the six oral singleton phonemes included in this study.

Table 3-3.
Realizations of singleton stops by phoneme (percentages)

Variable	*n*	**Allophone**						χ^2	*p*	*V*
		Stop	Fric. stop	Semi-fric.	Fric.	Approx.	Wk. approx			
Phoneme								440.22	<.000	.29
g	108	10%	9%	3%	26%	44%	8%			
k	231	4%	10%	--	62%	11%	12%			
d	126	35%	10%		19%	34%	2%			
p	197	25%	7%	7%	60%	1%	--			
t	232	27%	22%	4%	47%	--	--			
b	126	50%	6%	--	25%	16%	2%			

Table 3-4.
Realizations of singleton stops by phoneme (numbers)

Variable	*n*	**Allophone**						χ^2	*p*	*V*
		Stop	Fric. stop	Semi-fric.	Fric.	Approx.	Wk. approx			
Phoneme								440.22	<.000	.29
g	108	11	10	3	28	47	9			
k	231	10	23	0	144	26	28			
d	126	44	12	--	24	43	3			
p	197	49	14	14	119	1	--			
t	232	62	51	9	109	1	0			
b	126	63	8	--	32	20	3			
Totals	1020	239	118	26	456	138	43			

Pearson Chi-square tests indicate a significant difference among the phonemes in terms of their allophonic realization. From the tables below, it appears that the voiced labial /b/ and voiceless dental /t/ are least likely to lenite, and that most lenition occurs with the velars /g/ and /k/. The phoneme(s) most often occurring as a stop is /b/, as a fricative are /p/ an /k/, as an approximant are /d/ and /g/, and as a weak approximant segment /g/ and /k/. Cramer's *V*, which indicates the strength of the relationship between phoneme and allophonic category, is .29, so the effect size can be considered as medium according to Cohen (1988).

Two interesting observations surface in this analysis, as in all the crosstabulations to follow. Of the 1,020 oral singleton stops in this study, 637, or 63%, surface as either fricatives, approximants, or weak approximant segments. These numbers attest to overwhelming pervasiveness of lenition in the fluent speech of these Florentine subjects. That said, the fact that 239, or 23%, surface as full stops serves as a robust counterargument to any claim that spirantization is obligatory in intervocalic position, as formerly attested by Giannelli and Savoia (1978) and Kirchner (1998).

3.1.3 Allophonic variation by phonemic voicing

It has been observed throughout the literature (Giannelli & Savoia 1978, Lepschy & Lepschy 1977, Marotta 2001, and others) that the primary target of *Gorgia Toscana* is the class of voiceless stops. Table 3-5 and Table 3-6 confirm this observation, but offer a complication.

Table 3-5.
Realizations of singleton stops by voicing (percentages)

Variable	n	Allophone						χ^2	p	V
		Stop	Fric. stop	Semi-fric.	Fric.	Approx.	Wk. approx			
Voicing								208.26	<.000	.45
voiceless	660	18%	13%	4%	56%	4%	4%			
voiced	360	33%	8%	1%	23%	31%	4%			

Table 3-6.
Realization of singleton stops by voicing (numbers)

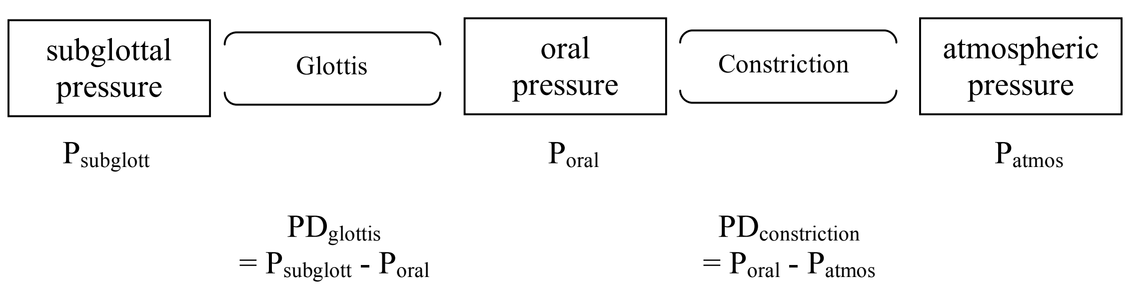
Variable	n	Allophone						χ^2	p	V
		Stop	Fric. stop	Semi-fric.	Fric.	Approx.	Wk. approx			
Voicing								208.26	<.000	.45
voiceless	660	121	88	23	372	28	28			
voiced	360	118	30	3	84	110	15			
Totals	1020	239	118	26	456	138	43			

The results of Chi-square tests are significant and the size of the relationship between voicing and allophonic variation can be assumed to be slightly larger than normal, given Cramer's $V = .45$. Voiced stops are much more likely to surface as stops than their voiceless counterparts, and voiceless fricatives are a considerably more common realization than voiced fricatives. Approximantization, however, is significantly more likely to occur when the underlying phoneme is voiced: 31% of the voiced stops surface as approximants, while only 4% of the voiceless stops exhibit this manifestation. This result is expected given the physics involved in producing voiced fricatives:

> ... during voicing the vocal cords are shut (or nearly so) as much as they are open. Therefore, given a comparable amount of air pressure produced by the lungs, the volume velocity during voicing is much lower than it is when the glottis is held open. Because a certain degree of airflow is necessary in order to produce turbulence, voiced fricatives may lose their frication, and become glides. (Johnson 1997:115)

This pattern is documented by Ohala (1983): fricatives require high volume velocity across the area of constriction; high volume velocity requires high pressure differential; high pressure differential across the oral constriction requires higher intraoral pressure; and higher intraoral pressure means less volume velocity and hence less adduction across the glottis. In other words, intraoral pressure needs to be simultaneously high enough to favor frication and low enough to favor voicing. The Aerodynamic Voicing Constraint's effect on simultaneous voicing and frication is illustrated in the schematic diagram in Figure 3-1.

Figure 3-1.
Schematic diagram of ACV



It comes as no surprise then, that voiceless stops generally weaken to fricatives, but voiced stops exhibit a higher rate of approximantization, as detailed in the tables above.

3.1.4 Allophonic variation by place of articulation

Table 3-7 and Table 3-8 illustrate a significant relationship between place of articulation and lenition.

Table 3-7.
Realizations of singleton stops by place (percentages)

Variable	*n*	Allophone						χ^2	*p*	*V*
		Stop	Fric. stop	Semi-fric.	Fric.	Approx.	Wk. approx			
Place								182.45	<.000	.30
velar	339	6%	10%	1%	51%	22%	11%			
labial	323	35%	7%	4%	47%	7%	1%			
dental	358	30%	18%	3%	37%	12%	1%			

Table 3-8.
Realizations of singleton stops by place (numbers)

Variable	*n*	Allophone						χ^2	*p*	*V*
		Stop	Fric. stop	Semi-fric.	Fric.	Approx.	Wk. approx			
Place								182.45	<.000	.30
velar	339	21	33	3	172	73	37			
labial	323	112	22	14	151	21	3			
dental	358	106	63	9	133	44	3			
Totals	1020	239	118	26	456	138	43			

As discussed in Chapter 1, several authors (Giannelli & Savoia 1978:43, Bafile 1997: 28, Anselmi 1989:60-61, Izzo 1972, Tolomei 1525 and 1547, and Rhys 1569) note the general tendency for velars to exhibit the most lenition (or any, in the case of 16th century Italian). This tendency, and the tendency for extreme weakening (approaching deletion) to occur only with velars, is supported in the present study's analysis of allophonic variation by place of articulation. Only 6% of velars surface as full stops, while 35% of labials and 30% of dentals surface in this manner. 22% of velars undergo approximantization, compared to 7% of labials and 12% of dentals. A considerably higher number of velars (11%) are realized as weak approximants than labials or dentals (1% each). Note also the relatively even distribution among surface realizations for the labials and dentals, in contrast with the skewed distribution of velars towards the weaker end of the allophone categories.

Some of the authors mentioned above, as well as Marotta (2001:31) and Sorianello (2001:82), take place effects a step further, asserting a specific asymmetry in *Gorgia* effects based on place of articulation. The generalization among these authors is that velars are the most likely segments to lenite, while labials are the least likely. The analysis reported here does not support the notion of a velar-dental-labial hierarchy in the area of consonant weakening: although dentals are more likely than labials to approximantize, place effects are the opposite in terms of lenition to fricatives. When the crosstabulations above are split by voicing, these effects become even more obvious, and it is clear that the velar-dental-labial hierarchy only holds for voiced segments, while among voiceless segments the hierarchy appears to be velar-labial-dental. Table 3-9 reports the percentages in each allophone category for /p/ and /t/, while Table 3-10 gives the same information for /b/ and /d/ (velars are omitted from the tables, since there is no debate as to their high place in the lenition hierarchy).

Table 3-9.
Realizations of voiceless singleton stops by place

Variable	*n*	Allophone					
		Stop	Fric. stop	Semi-fric.	Fric.	Approx.	Wk. approx
Place							
velar	231	4%	10%	--	62%	11%	12%
labial	197	25%	7%	7%	60%	1%	0%
dental	232	27%	22%	4%	47%	0%	0%

Table 3-10.
Realizations of voiced singleton stops by place

Variable	*n*	Allophone					
		Stop	Fric. stop	Semi-fric.	Fric.	Approx.	Wk. approx
Place							
velar	108	11%	10%	3%	28%	47%	9%
labial	126	50%	6%	0%	25%	16%	2%
dental	126	35%	10%	0%	19%	34%	2%

The above data are a strong indication that lenition patterns differently depending on underlying voicing.

3.1.5 Allophonic variation by lexical frequency

The cross-tabulations testing effects of lexical frequency and stress position in this and the following sections will be run using a slightly different method. Each of the tests must be run on individual phonemes, owing to the fact that phoneme categories are not necessarily distributed evenly in terms of frequency, prosodic domain, and stress position. The reason for this imbalance is the addition of several tokens to one specific independent variable cluster: in order to test for effects of vowel backness when V1 and V2 are identical, four tokens were added containing word-internal, low-frequency, voiceless oral stops with preceding stress. This augmentation of the token list for a specific variable cluster is seen in the token trees in Appendix B.

As splitting the statistical database into six phoneme groups results in a much smaller *N* for each group, the allophone categories have been collapsed into two groups: those exhibiting no or minimal lenition (stops, fricated stops, and semi-fricatives) and those exhibiting maximal lenition (fricatives, approximants, and weak approximant segments). This method gives exactly the results sought in terms of independent variable effects on lenition, and removes any bias brought about by unequal phoneme distributions.

It was expected that lexical frequency might play an important role in consonant weakening, and usage-based theories predict such an outcome. This expectation was realized for two of the phonemes - /k/ and /g/. A clear trend towards more lenition in high frequency tokens for these segments is seen in Table 3-11 through Table 3-16.

Table 3-11.
Realizations of /g/ by lexical frequency

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Lex. Freq.				3.43	.052	.18
low	54	30%	70%			
high	54	15%	85%			

Table 3-12.
Realizations of /k/ by lexical frequency

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Lex. Freq.				3.32	.049	.12
low	142	18%	82%			
high	89	9%	91%			

Table 3-13.
Realizations of /b/ by lexical frequency

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Lex. Freq.				1.55	.144	.11
low	72	61%	39%			
high	54	50%	50%			

Table 3-14.
Realizations of /d/ by lexical frequency

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Lex. Freq.				0.53	.293	.07
low	54	48%	52%			
high	72	42%	58%			

Table 3-15.
Realizations of /p/ by lexical frequency

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Lex. Freq.				0.13	.423	.03
low	143	40%	60%			
high	54	37%	63%			

Table 3-16.
Realizations of /t/ by lexical frequency

Variable	*n*	Lenition Minimal	Lenition Maximal	χ^2	*p*	Phi
Lex. Freq.				0.00	.536	-.00
low	162	53%	47%			
high	70	53%	47%			

3.1.6 Allophonic variation by prosodic domain

Prosodic domain has a significant effect on lenition for only one of the six oral singleton stops in the database, the voiceless dental stop /t/. No other trends toward more lenition in word-internal items is attested, at least in this qualitative assessment, as Table 3-17 through Table 3-22 indicate.

Table 3-17.
Realizations of /t/ by prosodic domain

Variable	*n*	Lenition Minimal	Lenition Maximal	χ^2	*p*	Phi
Pros. Dom .				5.503	.019	-.154
word	162	47.5%	52.5%			
phrase	70	64%	36%			

Table 3-18.
Realizations of /b/ by prosodic domain

Variable	*n*	Lenition Minimal	Lenition Maximal	χ^2	*p*	Phi
Pros. Dom .				1.68	.195	-.115
word	72	51%	49%			
phrase	54	63%	37%			

Table 3-19.
Realizations of /d/ by prosodic domain

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Pros. Dom .				0.00	1.00	.000
word	90	44%	56%			
phrase	36	44%	56%			

Table 3-20.
Realizations of /g/ by prosodic domain

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Pros. Dom .				2.17	.141	.142
word	72	26%	74%			
phrase	36	14%	86%			

Table 3-21.
Realizations of /p/ by prosodic domain

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Pros. Dom .				1.99	.158	-.101
word	144	36%	64%			
phrase	53	47%	53%			

Table 3-22.
Realizations of /k/ by prosodic domain

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Pros. Dom .				.991	.319	.066
word	143	16%	84%			
phrase	88	11%	89%			

3.1.7 Allophonic variation by stress position

Effects of stress position (left/preceding or right/following) can only be tested on tokens occurring word-internally. As mentioned previously, preceding stress in word-boundary tokens will always induce syntactic doubling in this dialect, thereby blocking lenition. *N* is consequently smaller in this series of tests.

Stress position has no significant effect on lenition for any of the phonemes tested. Details of the relationship are in Table 3-23 through Table 3-28.

Table 3-23.
Realizations of /b/ by stress position

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Stress				0.06	.500	.03
left	72	61%	39%			
right	54	50%	50%			

Table 3-24.
Realizations of /d/ by stress position

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Stress				2.53	.093	.17
left	54	48%	52%			
right	72	42%	58%			

Table 3-25.
Realizations of /g/ by stress position

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Stress				0.07	.500	-.03
left	54	30%	70%			
right	54	15%	85%			

Table 3-26.
Realizations of /p/ by stress position

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Stress				0.16	.417	-.03
left	143	40%	60%			
right	54	37%	63%			

Table 3-27.
Realizations of /t/ by stress position

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Stress				0.00	.559	.00
left	162	53%	47%			
right	70	53%	47%			

Table 3-28.
Realizations of /k/ by stress position

		Lenition				
Variable	*n*	Minimal	Maximal	χ^2	*p*	Phi
Stress				0.63	.417	.07
left	142	18%	82%			
right	89	9%	91%			

3.1.8 Allophonic variation by vowel backness

The tendency for consonants to lenite is nearly identical for those segments flanked by [+back] vowels as for those flanked by [-back] vowels. Chi-square tests run on a tightly controlled set of oral voiceless stops (those occurring word-internally, with stress on the left and low lexical frequency) result in no significant association. As with the tests in the previous two sections, lenition categories were collapsed into two categories in order to meet the assumptions required by these statistics. Table 3-29 illustrates that lenition occurs to the same extent, regardless of vowel place of articulation.

Table 3-29.
Cross-tabulations of vowel backness by lenition

Variable	*n*	Lenition: Minimal	Maximal	χ^2	*p*	Phi
V1/V2 backness				0.00	.542	.00
[-back]	89	36%	64%			
[+back]	126	36%	64%			

3.2 Qualitative analysis of geminate segments

This study finds that geminate segments show limited signs of weakening, and their weakening patterns are subtler than those of singleton segments. The geminates in this dataset do not, generally, weaken to fricatives, and never approximantize or delete. Because of the extremely low *N* (33) of geminates surfacing as anything other than stops, statistics are not run on the data, but the cases will be examined on an individual basis. Table 3-30 shows the details of the geminates that lenite in some way.

Table 3-30.
Cases of geminate lenition

Subject	Word	VCV seq	Phoneme	Allophone
AC	addirittura	addi	d	Fricated stop
AC	addirittura	addi	d	Semi-fricative
AC	agganciare	agga	g	Semi-fricative
AC	anni	anni	n	Fricative
AC	balbettare	etta	t	Fricated stop
AC	balbettare	etta	t	Fricated stop
AC	macchina	akki	k	Semi-fricative
AC	macchina	akki	k	Fricated stop
AC	macchina	akki	k	Fricated stop
AC	macchia	akkj	k	Fricated stop
AC	macchia	akkj	k	Fricated stop
AC	macchia	akkj	k	Fricated stop
AC	pappagallo	appa	p	Fricated stop
AC	abbastanza	abba	b	Fricated stop
GA	abbastanza	abba	b	Fricated stop
GA	addirittura	addi	d	Fricated stop
GA	agganciare	agga	g	Fricative
GA	macchina	akki	k	Fricated stop
GA	macchina	akki	k	Fricated stop
GA	macchina	akki	k	Fricated stop
GA	macchia	akkj	k	Fricated stop
GA	pappagallo	appa	p	Fricated stop
RG	agganciare	agga	g	Fricated stop
MA	agganciare	agga	g	Fricated stop
MA	agganciare	agga	g	Fricated stop
MA	agganciare	agga	g	Fricated stop
MA	abbastanza	abba	b	Fricated stop
LV	agganciare	agga	g	Fricated stop
LV	macchina	akki	k	Fricated stop
LV	macchina	akki	k	Fricated stop
LV	macchina	akki	k	Fricated stop
LV	blocchetto	okke	k	Fricated stop
LV	macchia	akkj	k	Fricated stop

There is an insufficient amount of data to support statistically sound conclusions; nevertheless, two interesting generalizations are observed. First, three tokens account for 21 out of 33 (64%) of the geminates surfacing as something weaker than a complete stop: *agganciare* ('to clasp'), *macchina* ('car'), and *macchia* ('stain'). The weakened geminate segment in each of these tokens is a velar – not surprising given the strong effects that place of articulation has on lenition. Second, voiceless geminates account for over half of the cases in Table 3-30 (58%). Again, this pattern does not conflict with that of singletons.

Although vowel backness appears to have a strong effect on geminate weakening, as each of the 33 cases involves geminates preceded by [+back] vowels, this is simply an artifact of the experiment. Because vowel place of articulation was only controlled for the subset of voiceless singleton tokens, it happens that a majority of the tokens involving geminates involve vowels that are [+back].

3.3 Outcome of hypothesis testing

Based on the tests discussed above, the six hypotheses that shaped the experimental design can be tested on a qualitative basis. These are:

H1: Velar consonants will lenite more than labials or dentals.

H2: Consonants in high frequency tokens will lenite more than consonants in low frequency tokens.

H3: Word-internal consonants will lenite more than items at word edges.

H4: Word-internal consonants with stress on the left will lenite more than word-internal items with stress on the right. (In other words, foot-medial consonants will lenite more than foot-initial consonants.)

H5: Consonants flanked by back vowels will lenite more than consonants flanked by front vowels.

H5: Geminate consonants will lenite to long fricatives.

The only hypotheses robustly confirmed by qualitative analysis of the data are H1, that velars lenite more than labials or dentals. H2, asserting that high-frequency lexical items are richer environments for lenition, is very weakly confirmed for velar segments only, and will be tested further in subsequent chapters. H3, that segments will lenite more in a word-internal environment than they will at a word boundary, is only upheld for one phoneme, /t/. The two hypotheses incorporating stress position and vowel backness are each rejected based on the qualitative tests described in Section 3.1. Whether geminates fricativize while retaining their characteristic length will be discussed in Chapter 5, which presents a quantitative analysis of the data in this study.

3.4 Dependent variables by allophone category

Recall that we expect weaker segments to exhibit decreased constriction and VOT durations (with the exception of fricatives, which as I will show pose a problem for this generalization), increased intensity and voicing, and higher rates of release burst absence. With these predictions in mind, this section focuses on measurements of duration, intensity, and voicing by allophone category.[33]

All figures are rounded to two decimal places for ease of interpretation. Note that relative constriction and relative VOT durations are NOT measured in

[33] Burst absent rates are not provided by allophone in this section because they are one of the determiners of allophonic categorization (e.g., any segment judged to be an approximant necessarily has no burst) as described in Chapter 2.

milliseconds; rather, they are figured as the ratio of actual constriction/VOT durations to actual durations of the entire VCV sequence (in order to normalize the data and remove rate effects). Relative intensity (in dB) is calculated by subtracting[34] mean utterance intensity from mean phoneme constriction intensity. As utterance intensity is almost always higher than constriction intensity for the segments measured, the intensity ratio will usually be a negative number, with intensity ratio rising as it approaches zero.

The variables measured in subsequent tables are coded as follows:

- CONSTR dur = mean relative constriction duration
- VOT dur = mean relative VOT duration
- TTL dur = mean total duration (constriction + VOT)
- Intensity = mean relative intensity ratio of phoneme constriction to utterance (negative numbers indicate that constriction intensity is less than utterance intensity; positive numbers indicate that constriction intensity is greater than utterance intensity)
- RPP = mean relative periodicity power (de-logged harmonics-to-noise ratio) of constriction (higher numbers indicate a greater amount of periodicity)

Chapter 2 addressed the obvious underlying differences in duration, intensity, and voicing depending on phonemic voicing. Such differences require that the quantitative correlates of allophones be measured separately based on these phonemic

[34] Subtraction is used to calculate intensity ratios because intensity is measured on a logarithmic, not linear, scale.

characteristics, and the data reported in the following sections is broken down into two subsets: 1) voiceless singletons and 2) voiced singletons.

3.4.1 Mean duration of constriction and VOT by allophone

Table 3-31 and Table 3-32 provide details on relative constriction, VOT, and total durations by allophone category for the voiceless singletons and voiced singletons, respectively.

Table 3-31.
Mean relative durations of voiceless singletons

Allophone	Valid N	CONSTR dur	VOT dur	TTL dur
Weak approximant	28	n/a	n/a	n/a
Approximant	28	.20	.00	.20
Fricative	368	.30	.00	.30
Semi-fricative	23	.27	.06	.33
Fricated stop	88	.18	.15	.33
Stop	120	.21	.12	.33

Table 3-32.
Mean relative durations of voiced singletons

Allophone	Valid N	CONSTR dur	VOT dur	TTL dur
Weak approximant	15	n/a	n/a	n/a
Approximant	108	.17	.00	.17
Fricative	81	.21	.00	.21
Semi-fricative	3	.13	.12	.25
Fricated stop	30	.19	.05	.24
Stop	118	.22	.03	.25

Fry (1979: 137)'s measurements of stop and fricative constriction duration predict the problematic nature of this duration measurement in terms of its reliability as a lenition indicator. In the case of voiceless singletons, the mean relative constriction duration of fricative allophones is .30 – much greater than the mean for stops and fricated stops at .21 and .18, respectively. Voiced singletons surfacing as fricatives have approximately the same, or sometimes greater, relative constriction duration as those surfacing as stronger allophones.

VOT duration patterns as we might expect, since this variable is correlated highly with burst absence rate. The interesting differences, however, occur only among the categories of fricated stops and semi-fricatives. However, the small number of tokens in these two categories, and the difficulty in assigning tokens to them, make the use of VOT problematic as an indicator of lenition.

Despite the lack of correlation between constriction and VOT durations and allophone category, combining the durations yields results that are much more in line with expectations of duration as a lenition indicator. For each of the groups of consonants, weaker allophones are consistently shorter in total relative duration than strong allophones; in fact, linear correlations of total relative duration by allophone category are robust in the case of singleton segments.

3.4.2 Mean intensity ratios by allophone

The general expectation that weaker allophones will have higher intensities is borne out by the data in this study, particularly for the group of voiceless singletons in Table 3-33.

Table 3-33.
Mean intensity ratio of voiceless singletons

Allophone	Valid N	Intensity
Weak approximant	28	n/a
Approximant	28	-4.98
Fricative	372	-13.95
Semi-fricative	23	-14.31
Fricated stop	88	-16.03
Stop	121	-17.80

The voiced singletons in Table 3-34 exhibit similar behavior, with one important exception: within this group, intensity is higher in stops than in fricatives, semi-fricatives, or fricated stops.

Table 3-34.
Mean intensity ratio of voiced singletons

Allophone	Valid N	Intensity
Weak approximant	15	n/a
Approximant	122	-4.52
Fricative	85	-9.00
Semi-fricative	3	-10.92
Fricated stop	30	-12.03
Stop	118	-8.39

Higher intensity during the constriction period of voiced stops seems counterintuitive, but may be more easily understood when we consider the physics involved in speech production. If the total amount of force in a system dictates how much energy there is available to be contributed to various components of that system (Fry 1979: 89), the energy devoted to producing the velocity required by fricatives is not available to produce increased amplitude. Of course this argument only applies to voiced segments, since the only possible source of sound during closure is voicing. (Johnson 1997:131) and closure of voiceless sounds involves little or no energy (Olive et al 1993:83). In addition, Pincas and Jackson (2004: 73) discuss amplitude modulation in dual-source signals (in this case, voicing and frication) and find, in line with Stevens et al (1992), that dual-source effects reduction in overall amplitude.

Although justified, the pattern of relative intensity found in allophonic variants of voiced stops is erratic, indicating that for this group of segments intensity may not be correlated tightly with weakening.

3.4.3 Mean relative periodicity power by allophone

As with intensity measurements, there is a trend for weaker variants to increase in relative periodicity power (that is, for their harmonics-to-noise ratio to become greater) within the phonemically voiceless group, although the difference in RPP is negligible among fricated stops, semi-fricatives, and fricatives, and only slightly lower in complete stops. Voiced segments exhibit a pattern similar to that involving intensity, as the stops surface with more voicing than any other allophones do. Table 3-35 and Table 3-36 provide the details.

Table 3-35.
Relative periodicity power of voiceless singletons

Allophone	Valid N	RPP
Weak approximant	28	n/a
Approximant	28	.93
Fricative	372	.70
Semi-fricative	23	.70
Fricated stop	80	.69
Stop	111	.66

Table 3-36.
Relative periodicity power of voiced singletons

Allophone	Valid N	RPP
Weak approximant	15	n/a
Approximant	109	.93
Fricative	85	.90
Semi-fricative	3	.76
Fricated stop	26	.82
Stop	114	.94

Voicing as a lenition indicator for the group of voiced segments does not appear a very reliable one. Despite this, the data actually make sense when we consider the inherent articulatory conflict of voicing and frication noted in Ohala (1983: 201):

> ...voiced fricatives have more exacting aerodynamic requirements than do voiced stops: For the sake of continued voicing the oral pressure should be low, but for the sake of frication the oral pressure should be high, that is, the difference between oral pressure and atmospheric pressure should be high enough to cause high air velocity through the consonantal constriction. Meeting both of these requirements simultaneously may be difficult.

Johnson (1997:115) makes a similar observation, and the result is that segments retaining voicing are less likely to be 'good' fricatives, while those segments retaining frication are likely to devoice. No wonder, then, that the noisier fricated stops and semi-fricatives are much lower in RPP than stops: frication is achieved in these two allophones at the expense of voicing. By this logic, the fricative variants should involve even less periodicity, but they do not. The likely explanation is that they are well on their way to becoming approximants, and losing the quality of 'good' fricatives. A rich cocktail of articulatory effects, then, is seen in the behavior of voiced segments with respect to how much they retain, increase, or decrease as they lenite. Unfortunately, this richness makes it quite difficult to use RPP as a reliable indicator of lenition for underlyingly voiced segments.

3.5 Comparing the present results with previous findings (Marotta, Sorianello)

The following sections compare the general results of this study with those of two other authors analyzing lenition using acoustic methods, Marotta (2001) on Pisan stops and those reported by Sorianello (2001) on Florentine.

3.5.1 Marotta 2001 – Pisan stop weakening

Marotta (2001) analyzes the allophonic variation and duration of segments from a portion of the *API* (*Archivio del Parlato Italiano*) database consisting of 1,633 tokens from five university-age native Pisan speakers, broken down as follows

voiced singletons: p = 363, t= 518, k= 436
voiced singletons: b = 96, d = 171, g = 49

The generalizations resulting from Marotta's study of voiced Pisan stops are generally similar to those presented in the previous sections, with two exceptions. Table 3-37 summarizes her findings with respect to allophonic variation. Note that Marotta uses only three allophone categories for voiced stops.

Table 3-37.
Realizations of voiced stop singletons by place of articulation
(Marotta 2001: 31)

		Allophone [35]					
Variable	*n*	Stop	Fric. stop	Semi-fric.	Fric.	Approx.	Del.
Phoneme							
/b/	96	81%			3%	16%	
/d/	171	67%			1%	32%	
/g/	49	37%			15%	48%	

With respect to place of articulation effects Marotta's results for the class of voiced oral singleton stops are not very far off from the results presented in Section 3.2 repeated below for ease of reference. Labial stops are most likely to maintain their manner of articulation, velars are most likely to lenite, and dentals fall somewhere in between. None of the voiced stops in her data undergo deletion, however; and those surfacing as fricatives are relatively few in number compared to those reported in the present study:

[35] Marotta classifies the surface variants of voiced stops in only three categories.

Table 3-38.
Realizations of voiced stop singletons by place of articulation
(present study)

		Allophone					
Variable	*n*	Stop	Fric. stop	Semi-fric.	Fric.	Approx.	Wk approx.
Phoneme							
/b/	126	50%	6%	--	25%	16%	2%
/d/	126	35%	10%	--	19%	34%	2%
/g/	108	10%	9%	3%	26%	44%	8%

With respect to duration of the voiced stop surface variant's Marotta's measurements of absolute durations are consistently shorter for weaker surface variants, as Table 3-39 shows. Durations in the present study (presented here as absolute mean durations for comparison's sake) follow the same pattern, with the exception of /d/, which does not appear to reduce in length when leniting to a fricative. (*N*s for voiced stops surfacing as fricatives in this dataset are small, however, which may account for the anomaly.

Table 3-39**.**
Mean absolute durations (ms) of voiced stop allophones
(Marotta 2001)

	Allophone		
Variable	Stop	Fric.	Approx.
Phoneme			
/b/	68	56	37
/d/	60	48	30
/g/	65	58	39

Table 3-40.
Mean absolute durations (ms) of voiced stop allophones
(present study)

	Allophone		
Variable	Stop	Fric.	Approx.
Phoneme			
/b/	66	50	47
/d/	50	52	42
/g/	62	50	38

With respect to voiceless stops, Marotta's results are somewhat incomplete. She reports the percentages of /p/, /t/, and /k/ surfacing as stops, fricatives, and weak approximant segments only. Average durations are not reported for these voiceless consonants. Nevertheless, referring to Table 3-41 and Table 3-42 we see very different results in Marotta's data and the present study with respect to labials. While Marotta's voiceless labials lenite only 14% of the time, those analyzed here do so at a rate of 75%. This difference may well be due to dialectal variations in the manifestation of *Gorgia Toscana* in different regions of Tuscany, as Sorianello (2001:83) observes.

Table 3-41.
Realizations of voiceless stop singletons by place of articulation
(Marotta 2001: 35)

		Allophone					
Variable	*n*	Stop	Fric. stop	Semi-fric.	Fric.	Approx.[36]	Del.
Phoneme							
/p/	363	84%			7%		
/t/	518	39%			28%		
/k/	436	20%			58%		5%

[36] No percentages of voiceless stops surfacing as approximants are found in Marotta (2001).

Table 3-42.
Realizations of voiceless stop singletons by place of articulation
(present study)

		Allophone					
Variable	*n*	Stop	Fric. stop	Semi-fric.	Fric.	Approx.	Wk approx.
Phoneme							
/p/	197	25%	7%	7%	60%	1%	--
/t/	232	27%	22%	4%	47%	--	--
/k/	231	4%	10%	--	62%	11%	12%

3.5.2 Sorianello 2001 – Florentine voiceless stop weakening

The data in Sorianello consists of 938 intervocalic voiceless stops (/p/, /t/, and /k/) broken down as follows: 326 labials, 336 dentals, and 276 velars. These data are also from a portion of the *API* database and consist of spontaneous (map-task) speech from six university-age Florentine students. In addition to characterizing each token as one of eight surface variants, Sorianello reports measurements of consonant duration and relative intensity.

While Marotta's allophone categories are collapsed into the set of stops, fricatives, and approximants, Sorianello has expanded the number of allophonic variants to eight. These differences in granularity, given the present study's 6-category allophone analysis, make direct comparisons difficult, but these authors' data is presented as originally published rather than collapsed.

Table 3-43.
Realizations of voiceless stop singletons by place of articulation
(Sorianello 2001: 71)

Variable	*n*	**Allophone**							
		-voi stop	Unreleased stop	Weak stop	+voi stop	-voi fricative	+voi fricative	Approx.	Del.
Phoneme									
/p/	326	10%	5%	16%	5%	37%	22%	6%	--
/t/	336	--	--	1%	1%	72%	13%	12%	1%
/k/	276	--	--	1%	1%	28%	11%	50%	10%

Table 3-44.
Realizations of voiceless stop singletons by place of articulation
(present study)

Variable	*n*	**Allophone**					
		Stop	Fric. stop	Semi-fric.	Fric.	Approx.	Wk approx.
Phoneme							
/p/	197	25%	7%	7%	60%	1%	--
/t/	232	27%	22%	4%	47%	--	--
/k/	231	4%	10%	--	62%	11%	12%

There are two obvious differences in Sorianello's findings as compared to those of the present study. Extremely few dentals (2%) surface as any type of stop in Sorianello's dataset, while the dentals in the dataset described here do so about half of the time. This difference is very likely attributed to the lack of morphological controls in Sorianello's study of the *API* data. It was argued earlier that that /t/-weakening in specific morphological contexts (weak past participles, 2nd person plural verb inflections, and the nominal derivational suffix /-ta/) should be viewed as a process distinct from post-lexical lenition. These particular contexts are illustrated in Example 3-1(a-c).

Example 3-1.
/t/ weakening
(Giannelli & Savoia 1978: 35, 1991:7)

a.	*bevut̠o*	pp. of *bere* 'to drink'
b.	*fate*	2^{nd} P plur. of *fare* 'to do'
c.	*labbrata*	'slap (to the mouth)'

While Sorianello's data may include /t/ in a number of these extremely weak contexts, none of the tokens analyzed in the present study do. The difference in methodological controls very likely also accounts for the fact that Sorianello's dentals lenite at a much higher rate than her labials, while the patterns in the present study are the opposite.

There is a much greater rate of approximantization for all three voiceless stops in the Sorianello data. This inconsistency may be due to age differences in Sorianello's and the current study's subject pools. Antelmi (1989: 62) observes "The tendency (among younger speakers) is towards a more open articulation, while for the older generation the pronunciation is much more fricated.''[37]

With respect to duration and intensity, Sorianello's findings are in line with the present study's: approximants are shorter in duration and higher in intensity than fricatives. She does not provide measurements for any of the varieties of stops, however.

[37] 'La tendenza [per i giovani] verso una apertura sempre maggiore del canale orale, mentre per le vecchie generazioni la pronuncia e' piu' francamente 'fricativa.'

3.5.3 General comparison of present and past results

The most striking contradiction in the present findings and those of Marotta (2001), Sorianello (2001, 2003) and Giannelli and Savoia (1978) is that these authors consistently find that the dental /t/ is more subject to *Gorgia* effects than the labial /p/, while the data here indicates a trend in the opposite direction. Because the study herein is the only one that includes morphological controls on the set of analyzed tokens, it is possible that the labial/dental in previous studies weakening order can be attributed to morphological differences. Also, Marotta presented data for Pisan Italian, not Florentine.

Bar charts showing the percentages of each voiceless phoneme in terms of allophonic distribution in the present study are in Figure 3-2 through Figure 3-4.

Figure 3-2.
Allophonic distribution of /p/

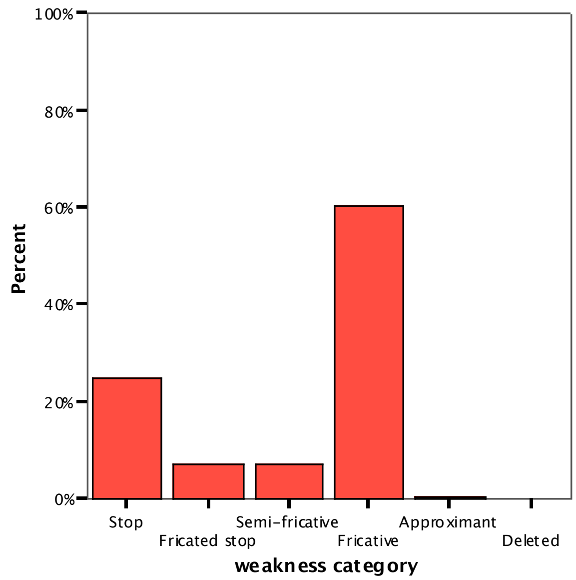


Figure 3-3.
Allophonic distribution of /t/

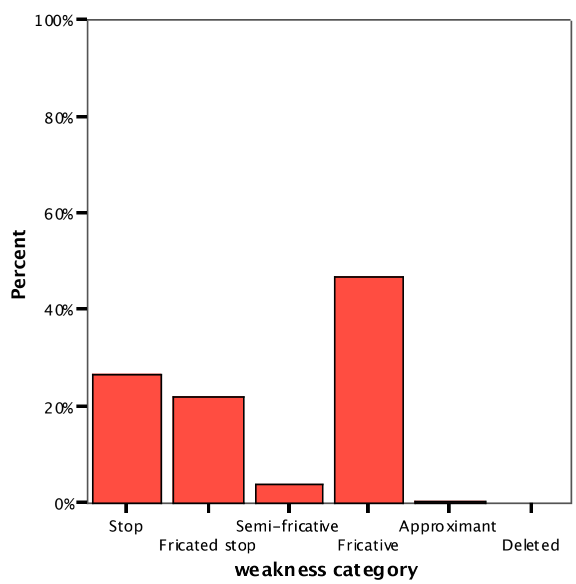
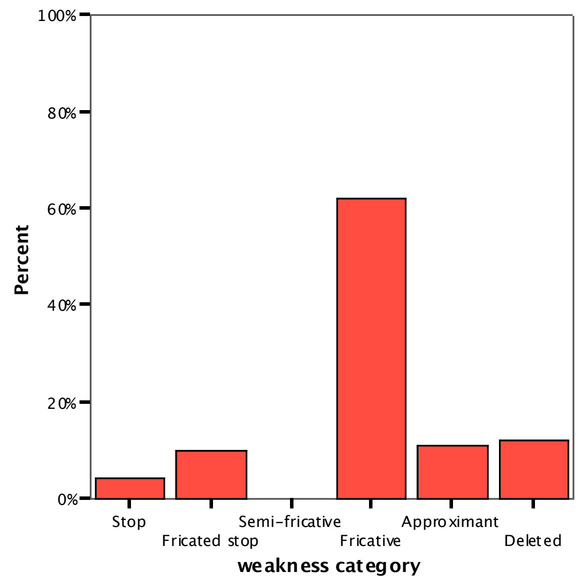


Figure 3-4.
Allophonic distribution of /k/



However, voiced singleton stops /b/, /d/, and /g/ in the present study exhibit patterns more similar to those found in Marotta (2001), with labials tending to be the least lenited segments. Allophonic distributions of voiced phonemes are displayed in Figure 3-5 through Figure 3-7.

Figure 3-5.
Allophonic distribution of /b/

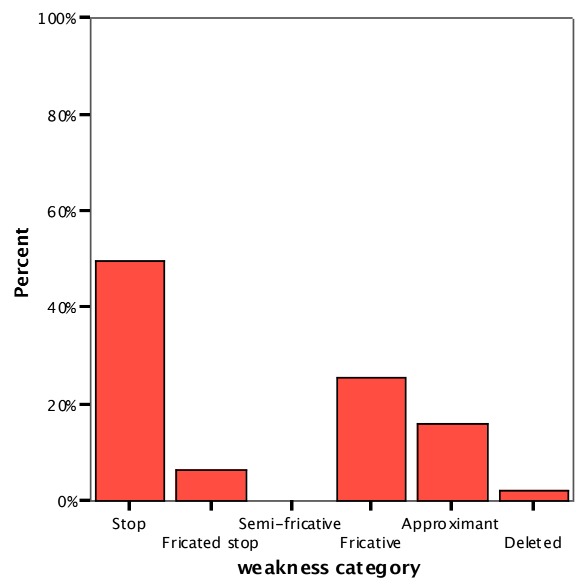


Figure 3-6.
Allophonic distribution of /d/

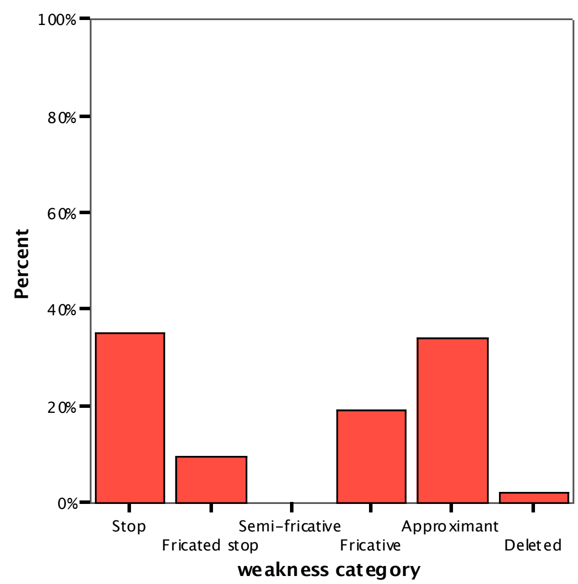
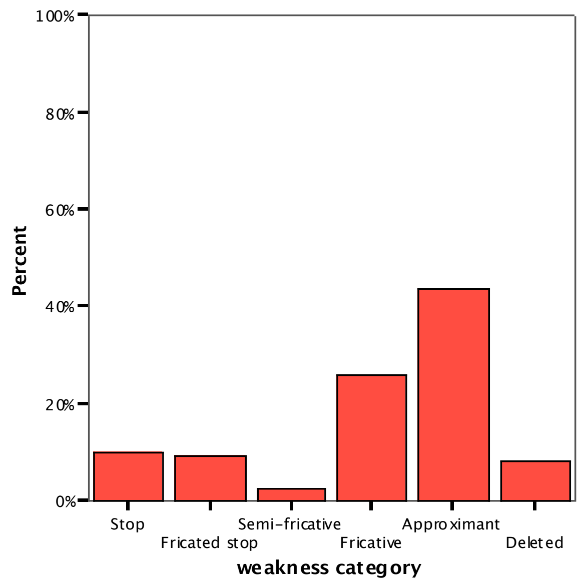


Figure 3-7.
Allophonic distribution of /g/



3.6 Patterns and generalizations, good indicators and bad

If an objective account of lenition is to be produced, we must first assess the reliability of the quantitative measures at our disposal. In other words, we need to establish that duration, intensity, and relative periodicity power pattern with allophonic distribution in a predictable way. If any of these variables does not, we run the risk of drawing spurious conclusions regarding the effects of *Gorgia* on the various sounds this study has set out to investigate. With this in mind, this section summarizes the results of Section 3.3 and addresses the predictive strength of each acoustic measurement.

3.6.1 Assessing the predictive power of dependent variables

For each token, relative durations of constriction and VOT with respect to the duration of the VCV sequence were measured, and the total relative consonant duration (constriction + VOT) was calculated from these. Relative intensity and relative periodicity power were also measured, and a burst absence code of '1' if there was no visible burst in the spectrogram, and '0' if there was a burst was assigned.[38] The detailed results of these measurements for each of the six surface variants (weak approximant, approximant, fricative, semi-fricative, fricated stop, and stop) were presented in Section 3.4.

3.6.2 Lenition indicators for voiceless stops

Measurements of dependent variables by allophone for /p/, /t/, and /k/ are reiterated in Table 3-45. The shaded areas represent those variables showing a clear pattern with respect to the allophone categories on the left.

[38] This system of coding the dichotomous variable BURST ABSENCE results in higher numbers for the variable indicating more lenition.

Table 3-45.
Dependent variables by allophone (voiceless oral singletons)

Allophone	CONSTR dur	VOT dur	TTL dur	Intensity	RPP	Burst Absence
Weak approximant	n/a	n/a	n/a	n/a	n/a	1.00
Approximant	.20	.00	0.20	-4.98	.93	1.00
Fricative	.30	.00	0.30	-13.95	.70	0.99
Semi-fricative	.27	.06	0.33	-14.31	.70	1.00
Fricated stop	.18	.15	0.33	-16.03	.69	0.00
Stop	.21	.12	0.33	-17.80	.66	0.02

Weak approximant consonants (N=28) cannot be segmented; hence, data cannot be measured.

For the class of voiceless oral singletons, neither constriction duration nor VOT duration on its own serves to indicate weakening in a reliable way: with the exception of approximants, which have the shortest constriction duration by far, constriction duration *increases* as segments weaken, while VOT duration shows a slight tendency to *decrease*. If one were to use constriction duration as an indicator of lenition, segments surfacing as a fricatives would be judged stronger than segments surfacing as stops. VOT duration as an indicator would result in segments manifested as fricated (leaky) stops generally assessed as stronger than sounds involving complete closure. Not only would measurements of constriction and VOT duration yield conflicting results with respect to each other, they would yield results that contradict general assumptions about what it means for a consonant to weaken: incomplete closure would be taken as a sign of strength, not weakness.

With respect to total relative duration of consonants, we see a much more consistent (and expected) behavior pattern: although there is no significant difference in duration among the three strongest allophones, weaker variants are progressively shorter.

Relative intensity of voiceless stop allophones also meets expectations. There is a minimal contrast in the intensity of fricatives and semi-fricatives (probably due to the very low *N* (23) of the latter, and the fact that these two allophones are minimally different in terms of their acoustic characteristics). Generally, however, segments increase in intensity as they weaken.

There is also a consistent, if not robust, relationship between weaker allophones and higher relative periodicity power (RPP). Although the three variants exhibiting frication (fricatives, semi-fricatives, and fricated stops) do not exhibit significant variation in RPP, there is an obvious trend for weaker segments to increase in periodicity-to-noise ratio.

Since release burst absence is one of the factors used in classifying tokens into allophone categories, it is no surprise that weaker segments have burst absence rates of 1 (or close to 1), while stronger segments have burst absence rates of 0. Because burst absence can be judged with a fair amount of objectivity based on spectrogram analysis, however, the circularity of burst patterns by allophone does not necessarily demand that this variable be treated as an unreliable predictor of lenition. It appears, in fact, to be one of the most reliable.

To sum up then, there are four dependent variables that reflect, albeit to different degrees and with differing robustness, the surface manifestation of voiceless stops. The are: total relative duration, relative intensity, RPP, and burst absence. The predictive strength with which each of these measurements contrasts allophonic variation is best shown graphically in Figure 3-8.

Figure 3-8.
Homogeneous subsets of voiceless stops predicted by dependent variables

Total relative duration:

$\boxed{\text{approximant}}$ $\boxed{\text{fricative}}$ $\boxed{\text{semi-fricative} \quad \text{fricated stop} \quad \text{stop}}$

Intensity:

$\boxed{\text{approximant}}$ $\boxed{\text{fricative} \quad \text{semi-fricative}}$ $\boxed{\text{fricated stop} \quad \text{stop}}$

RPP:

$\boxed{\text{approximant}}$ $\boxed{\text{fricative} \quad \text{semi-fricative} \quad \text{fricated stop}}$ $\boxed{\text{stop}}$

Burst absence:

$\boxed{\text{approximant} \quad \text{fricative} \quad \text{semi-fricative}}$ $\boxed{\text{fricated stop} \quad \text{stop}}$

This group of variables is sufficient because its members are those which indicate lenition with some degree of reliability; it is necessary because each variable's predictive power with respect to allophonic variation is different. The set will constitute the input for the Principal Components Analysis discussed in the following chapter.

3.6.3 Lenition indicators for voiced stops

Table 3-46 summarizes the dependent variable measurements for {/b/,/d/,/g/}, as detailed in Section 3.3. Again, the shaded areas indicate those dependents that pattern with allophones in a consistent, directional manner.

Table 3-46.
Dependent variables by allophone (voiced oral singletons)

Allophone	CONSTR dur	VOT dur	TTL dur	Intensity	RPP	Burst Absence
Weak approximant	n/a	n/a	n/a	n/a	n/a	1.00
Approximant	.17	.00	0.17	-4.52	.93	1.00
Fricative	.21	.00	0.21	-9.00	.90	1.00
Semi-fricative	.13	.12	0.25	-10.92	.76	1.00
Fricated stop	.19	.05	0.24	-12.03	.82	0.00
Stop	.22	.03	0.25	-8.39	.94	.09

Weak approximant consonants (N=15) cannot be segmented, data cannot be measured.

As with the set of voiceless oral singletons, relative constriction and VOT durations on their own do not reliably predict the strength of surface variants. Total relative duration is a much better indicator of strength or weakness, although it does not serve to contrast the three strong categories of semi-fricatives, fricated stops, and stops (however, *N* is particularly low for voiced segments surfacing as semi-fricatives (3) and as fricated stops (30)). Its predictive power is limited to contrasts between approximants, fricatives, and the stronger categories.

The real difference between voiceless and voiced segments lies in the failure of relative intensity and RPP to predict weakening in the latter set. As Table 3-46 illustrates, both intensity and RPP are greater for stops than for any other category except approximants. If either of these variables were incorporated into the assessment of weakening, the spurious conclusion that stops were somehow weaker than fricatives would result (or, more likely, the trends indicated by these measurements would conflict with those indicated by duration and burst absence, resulting in statistically insignificant outcomes). Articulatory explanations for the problematic nature of intensity and RPP within the set of voiced stops and their allophones have been addressed in Section 3.3.

Release burst absence rate is subject to both the criticism and justification mentioned above, with respect to its correlation with weaker categories, but in light of the lack of reliable lenition indicators for the set of voiced stops it must be retained.

The only two dependent variables, then, having some amount of predictive strength for allophonic variation, are total relative duration and release burst absence rates. The manner in which these two variables predict surface variants is graphically displayed in Figure 3-9. This small set of variables appears to be both necessary and sufficient with respect to its ability to explain variance in the data.

Figure 3-9.
Homogeneous subsets of voiced stops predicted by dependent variables

Total relative duration:

approximant | fricative | semi-fricative fricated stop stop

Release burst absence:

approximant fricative semi-fricative | fricated stop stop

3.6.4 Why not analyze voiced and voiceless tokens together?

Given the significant differences in the underlying characteristics of voiced and voiceless segments with respect to duration, intensity, and RPP, it is not possible to collapse the two groups and run quantitative analysis of lenition on the resulting set of oral singletons. A quick look at the dependent variable means of the two subsets is sufficient to demonstrate this.

Table 3-47.
Dependent variables by voicing (oral singletons)

Voicing	CONSTR dur	VOT dur	TTL dur	Intensity	RPP	Burst Absence
voiceless	.26	.05	0.31	-14.59	.70	.68
voiced	.20	.02	0.22	-7.66	.92	.62

Suppose we were to run tests on relative total duration, relative intensity, and RPP, assuming that shorter durations and higher intensity and periodicity-to-noise ratios indicate greater degrees of weakening. The outcome would be decidedly uninteresting: underlyingly voiced segments would be identified as those undergoing the most weakening, *precisely because they are weaker to begin with*. Where there is relatively little difference among {/p/,/t/,/k/} in terms of phonemic duration, intensity, and periodicity, and little difference among {/b/,/d/,/g/} for these same phonemic qualities, the contrast between voiceless and voiced phonemes is significant.

Furthermore, the analysis above has shown that while increased intensity and RPP are excellent indicators of lenition within the class of voiceless stops, these measurements fail to predict weakening in the voiced set. As a final justification for the independent treatment of tokens based on phonemic voicing, it will test whether *Gorgia Toscana* targets voiceless segments to a greater degree than it does their voiced counterparts.

With these descriptive statistics of allophones and dependent variable patterns concluded, Chapter 4 introduces a reliable method of quantitative analysis of the data in this study.

4 Quantification of lenition in the dataset

This chapter presents a new method of measuring lenition in a quantitative manner, using the latent variable scores derived via Principal Components Analysis (PCA). Section 4.1 furnishes the reader with background information on the concept of latent variables and the statistical tools available to discover such variables. Section 4.2 presents a justification for considering lenition a latent variable based on the descriptive statistics discussed in the previous chapter. The assumptions and methods used in factor analysis are discussed in Section 4.3, and the final section presents descriptive statistics on the data in this study using the resulting latent variable scores.

4.1 Background on latent variables and factor analysis

4.1.1 Latent variables versus observable variables

Latent variables can be found with exceptionally high frequency in various subfields of the social sciences. Consider the concepts of economic strength, intelligence, familial happiness, or second language proficiency – all concepts that are often discussed both in academic literature and everyday conversation. Although one can discuss such concepts easily, the matter of defining them is quite difficult: what does it mean for a country to have a strong economy? for a student of Spanish to be proficient?

Now consider another class of items – interest rates, math test scores, how often a family dines together, vocabulary size. The crucial difference between this set and the group of concepts mentioned above is that items such as rates, scores, time, and size can be directly observed and measured while the concepts in the previous paragraph cannot. It is this difference that is fundamental to the concept of latent variables.

Van der Linden (1992: 213) states "The more interesting variables in our disciplines are always latent and we are never able to observe them in a direct way" and Vermunt & Magidson (2003) offer constructs such as preferences, attitudes, behavioral intentions, and performance as typical examples of latent variables.

The difference in measurability between latent and observable variables entails a further generalization: latent variables are typically smaller sets of variables that underlie those variables that are actually measured (Leech et al 2005: 76). The many statistical methods used in detecting latent variables, therefore, are chiefly concerned with "whether the covariances or correlations between a set of observed variables can be explained in terms of a smaller number of unobservable constructs" (Landau and Everitt 2003: 284). Stated in simpler terms, these methods have efficiency as their goal: we can measure several different variables and test our hypotheses using each of them, but it is much more cogent to reduce these several variables to a group of one or two, and subsequently run our tests on the resulting smaller set. This parsimony is one of the benefits of data reduction.

The incorporation of latent variables into this study carries with it a caveat: latent variables are hypotheses about reality, not empirical quantities (Van der Linden 1992:231). Thus the result of data reduction in this study, while a useful construct for the purposes of testing hypotheses about lenition, is not to be understood as a measurement on any observable scale. It is constructed by way of analyses performed on the observable variables and is a hypothetical expression of the relationships among these observables. A latent variable is very useful, and quite often we can assign it a meaningful name, however it is by definition not a concrete, but an abstraction and an idealization.

4.1.2 Principal Components Analysis as a data reduction method

There are several methods at the statistician's disposal that can be used to assess the relationships among a larger set of variables. One of them, Principal Components Analysis, seems particularly appropriate for the data in the present study given the large number of measurements involved in the study's acoustic analysis, and this section briefly describes it.

Leech et al (2005: 76) present the end goal of Principal Components Analysis (PCA) as the mathematical derivation of a "relatively small number of variables" from the variables that were actually measured. Landau and Everitt (2003: 282) describe PCA as "essentially a method of data reduction that aims to produce a small number of derived variables that can be used in place of the larger number of original variables to simplify subsequent analysis of the data." According to these authors, the output of PCA (the principal components themselves) are combinations of the original variables that serve one primary purpose – to account for as much variation in the original data as possible.

A few important conditions and assumptions must be met if PCA is to be used appropriately. The conditions are that 1) a relationship (correlation) exists among the original variables and 2) the sample size must be relatively large in relation to the number of original variables (Leech et al 2005; Landau and Everitt 2003). Three criteria, which can be tested in the process of running PCA, assure that these conditions are met.

> Assumption 1: The *determinant*, derived from a correlation matrix of the original variables, indicates whether any of these variables is a linear combination of others. The *determinant* must be greater than .00001.
>
> Assumption 2: The *Kaiser-Meyer-Olkin* (KMO) measure of sampling adequacy indicates whether a sufficient number of items are actually predicted by each factor. The KMO measure should be greater than .70, and <u>must</u> be greater than .50.
>
> Assumption 3: *Bartlett's Test of Sphericity* tests whether the original variables are correlated highly enough to provide a reasonable basis for factor analysis (but not so highly that they are identical). The Bartlett test should be significant (< .05).

If each of the assumptions for PCA is met, we can run PCA to find underlying components (latent variables). Hatch and Lazaraton (1991:491) offer a straightforward account of the process, which is fundamentally based on correlation. In the SPSS[39] software used in the present study, PCA generates a correlation matrix of all the measured variables used as input and tests the assumptions above, as shown in Table 4-1 and Table 4-2. The hypothetical data here are taken from examples in Leech et al (2005: 85).

Table 4-1.
Correlation matrix of math achievement scores

		High school grades	Math ach. test	Pattern test	Visual. test	SAT – math
Correlation	High school grades	1.000	.504	-.012	.162	.371
	Math achievement test	.504	1.000	.213	.465	.788
	Pattern test	-.012	.213	1.000	.045	.110
	Visualization test	.162	.465	.045	1.000	.436
	SAT – math	.371	.788	.110	.436	1.000

a Determinant = .199

Table 4-2.
Tests of assumptions for math achievement scores

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.615
Bartlett's Test of Sphericity	Approx. Chi-Square	111.440
	df	10
Sig.		.000

Table 4-1 shows that all variables are significantly correlated and whether the determinant is greater than .00001. Table 4-2 verifies whether Assumption 2 and 3 are

[39] *Statistical Package for the Social Sciences*

met. The software then searches through the tested data to find a new variable, called a *component*, that accounts for as much variability as possible, and assigns a value to this first component. The resulting value tells us how much of the variability is accounted for by this first component, and is called the *eigenvalue* of the component.

After a first component is extracted and assigned an eigenvalue, SPSS searches for additional components that are not correlated with the first (or any others). Eigenvalues are assigned to each of the subsequent components, and there will be as many components as there are original tests (variables). The output generated by this process of searching for and assessing components indicating math achievement is in Table 4-3, from Leech et al (2005: 86). Note that a characteristic of PCA is that the cumulative percentage of variance explained by all components will always equal 100%.

Table 4-3.
Total Variance Explained for math achievement scores

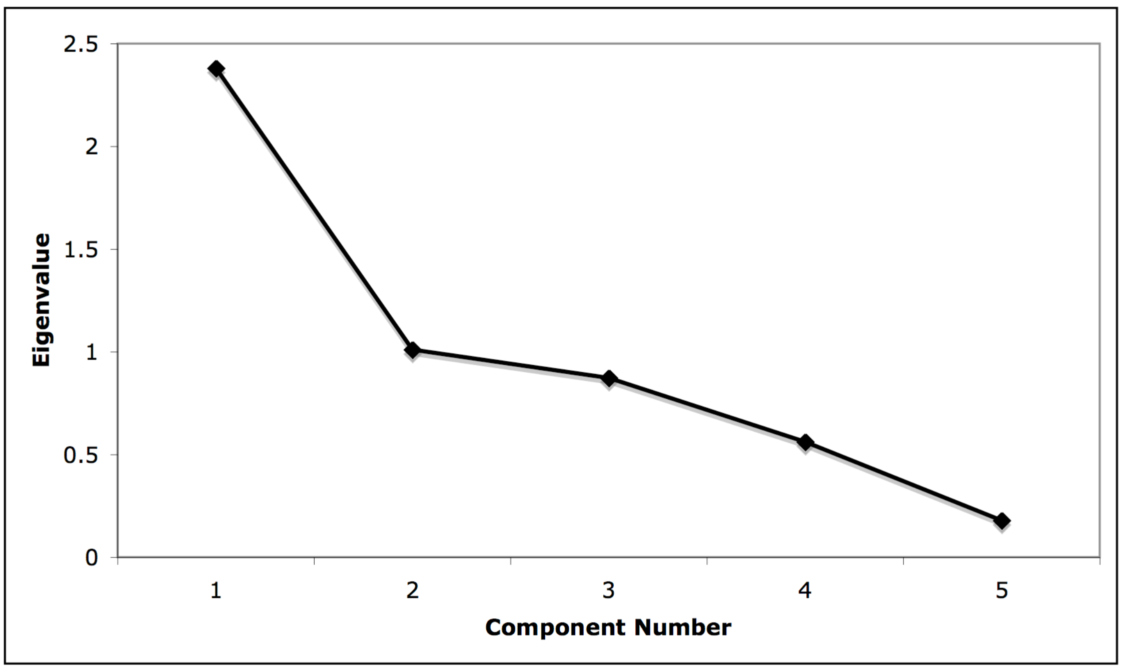
		Initial Eigenvalues		
Component		Total	% of Variance	Cumulative %
	1	2.379	47.579	47.579
	2	1.010	20.198	67.777
	3	.872	17.437	85.214
	4	.560	11.197	96.411
	5	.179	3.589	100.000

Extraction Method: Principal Component Analysis.

This substantive output lists each of the principal components (or factors) and tells us how much of the original variables' variance is explained by each component.

The most important piece of information in this output is the eigenvalue assigned to each factor, as this value is used to quantify the explained variance. Eigenvalues greater than 1.0 indicate that a factor, which is a latent variable, explains more variance than a single original variable explains (Leech et al 2005: 82), and Kaiser (1960) proposes the use of eigenvalues over 1.0 as a criteria for deciding which component(s) to keep. Figure 4-1 graphs the eigenvalues in Table 4-3 (Leech et al 2005: 86).

Figure 4-1.
Scree plot of components and *eigenvalues*



Cattell's Scree Test (Cattell 1966: 245) in Figure 4-1 illustrates that after the first two components (with eigenvalues of 2.379 and 1.010), the differences between the eigenvalues decline greatly. Components 3, 4, and 5 each have eigenvalues of less than 1.0, and are relatively similar in their ability to account for variation in the data, particularly compared with Components 1 and 2. Note the visible "elbow" in the plot – Cattell's test effectively tells us to use the components before the elbow, and discard those after.

Finally, the first two components in this example explain 68% of the variance in the data. While this may not seem a high number, it is vastly greater than the amount of variance explained by the next component or any other components thereafter. Since both the eigenvalues and the scree plot are well-accepted criteria for choosing components, Leech et al (2005) argue that we can reliably keep Components 1 and 2, thereby reducing five observed variables to two latent variables and simplifying data analysis.

4.2 Justification for lenition as a latent variable

Lavoie finds reduction in duration and increase in the intensity of periodic noise 2001: 164) to be two primary acoustic correlates of lenition. She also concludes (2001: 159) that a broad sonority scale akin to that of Zec (1988) or Clements (1990), which effectively groups segments into the categories of obstruent, sonorant, and vowel, is an appropriate method of capturing certain phonetic features of lenition, such as increased intensity. It should be obvious that such a scale also entails a higher rate of release burst absence as sounds become more sonorous (and weaker).

This study measured the four acoustic features of duration, intensity, periodicity, and burst absence for each token under investigation, basing the choices of acoustic features primarily on Lavoie's findings. The goal of this dissertation, however, is not to discover the exact phonetic ingredients of consonant lenition, but rather to test a number of hypotheses about segment type, prosody, and lexical frequency using lenition as the dependent variable. In order to carry out this goal, a quantitative construct of lenition is required – a hypothetical, but well-grounded in observable reality, latent variable.

The remainder of this chapter is devoted to the calculation of such a latent variable –L – and the presentation of descriptive statistics using L as a basis.

4.3 Principal Components Analysis in the present study

Chapter 3 presented a justification for the separate analysis of voiceless and voiced singleton stops based on the fact that they possess very different underlying qualities in terms of duration and voicing and also on the fact that intensity and RPP correlate with weakening categories for the set of voiceless stops, but not for the voiced set. Independent analysis of singleton stops by voicing is not only necessary, but also feasible for two reasons. First, the hypotheses to be tested in this study do not require a comparison of voiceless and voiced segments (i.e., there is no hypothesis "Voiced stops will lenite more/less than voiceless stops"). Second, the database is sufficiently large that splitting it does not result in *N*s too small to be adequate for statistical analysis. The sections that follow present the details of running Principal Components Analysis (PCA) on the two independent sets of data.

4.3.1 PCA of voiceless oral singletons - method

Using SPSS software, PCA was run on the subset of voiceless oral singletons (/p/, /t/, and /k/) with the only four input variables that appear to have some obvious relationship to weakening in this segment group, as discussed in Chapter 3:

- relative total phoneme duration = (constriction duration + VOT duration)/ VCV duration
- relative intensity = mean intensity in dB of constriction - mean sentence intensity in dB
- relative periodicity power = de-logged value of the segment's harmonics-to-noise ratio
- release burst absence

From the descriptive statistics presented earlier, it appears that relative total phoneme duration decreases as segments weaken, while intensity, voicing, and burst absence increase.

All of the assumptions pass the tests required by PCA, as illustrated in Table 4-4 and Table 4-5.

Table 4-4.
Correlation matrix of duration, intensity, RPP, and burst absence

		Relative total duration	Intensity ratio	RPP	Burst absence
Correlation	Relative total duration	1.000	-.339	-.211	-.230
	Intensity ratio	-.339	1.000	.304	.302
	RPP	-.211	.304	1.000	.110
	Burst absence	-.230	.302	.110	1.000
Sig. (1-tailed)	Relative total duration		.000	.000	.000
	Intensity ratio	.000		.000	.000
	RPP	.000	.000		.003
	Burst absence	.000	.000	.003	

a Determinant = .705

Table 4-5.
Tests of assumptions

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.657
Bartlett's Test of Sphericity	Approx. Chi-Square	212.163
	df	6
Sig.		.000

The determinant of .705 is greater than .0001, indicating that none of the input variables is a linear combination of the others. The Kaiser-Meyer-Olkin (KMO) measure is .657 – not greater than the suggested .70, but well over the .50 required minimum. And the Bartlett test used to assure that the variables are correlated highly enough is significant at $p < .001$. Note that when PCA was run with the inclusion of relative constriction duration and relative VOT duration, the assumptions did NOT pass these tests.

PCA returns one component with an Eigenvalue over 1 (in this case 1.763) that accounts for 44% of the variance in the data, as illustrated in the SPSS output in Table 4-6. While this number may not seem high, it is approximately twice the amount of the variance explained by the next component.

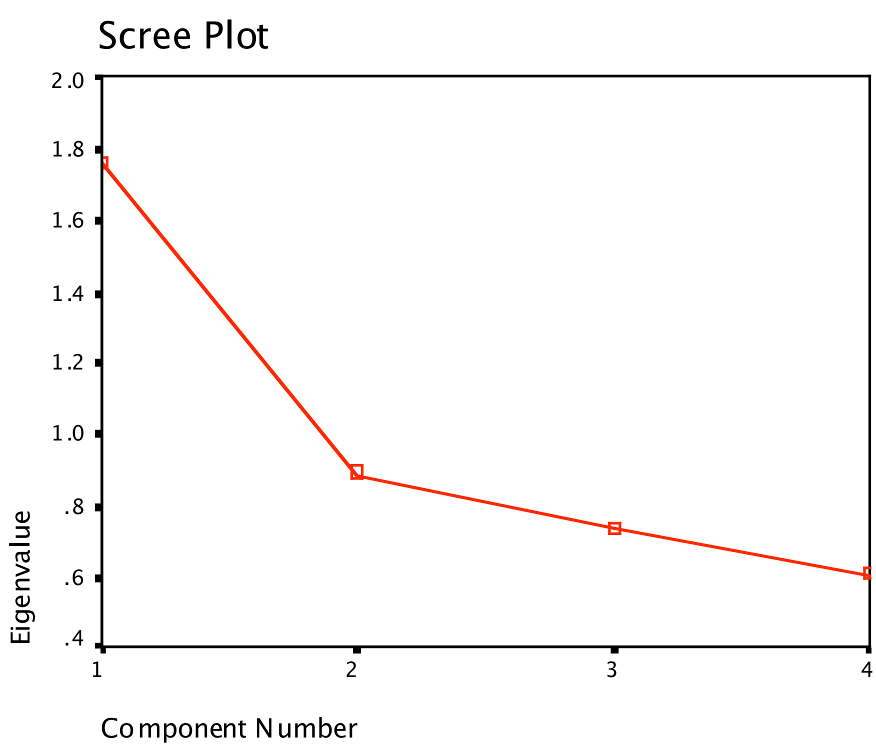
Table 4-6.
Total Variance Explained (voiceless oral singletons)

	Initial Eigenvalues		
Component	Total	% of Variance	Cumulative %
1	1.763	44.083	44.083
2	.891	22.263	66.346
3	.739	18.479	84.824
4	.607	15.176	100.000

Extraction Method: Principal Component Analysis.

The Scree plot in Figure 4-2 also indicates the relative strength of Component 1.

Figure 4-2.
Scree plot of components and *eigenvalues* (voiceless oral singletons)



Based on the eigenvalues and scree plot, only Component 1 was extracted, defined as a new variable, and renamed L_{ptk}. SPSS furnishes the component loading matrix in Table 4-7 that illustrates how L_{ptk} is defined in terms of the original observed variables.

Table 4-7.
Component Score Coefficient Matrix for L_{ptk}

	L_{ptk}
Relative total duration	-.388
Intensity ratio	.439
RPP	.331
Burst absence	.339

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Component Scores.

From this table, we can see that L_{ptk} is negatively loaded ("loading" defined as how an original variable affects an extracted component, or latent variable) with the original variable of relative total duration. It is positively loaded with the variables of intensity, RPP, and burst absence. A negative loading with duration means that tokens with *higher* durations are *lower* in L_{ptk} scores, and the positive loadings mean that tokens with higher intensity, RPP, and burst absence are higher in L_{ptk} scores. The loadings themselves are generally in the same range, with duration and intensity loadings on the high side. Leech et al (2005:83) present the criteria for low loadings at |.30| and for high loadings at |.40|.

After performing PCA, SPSS saves an L_{ptk} score for each token in the database. This score is a standardized weighting based on the component loading in Table 4-7.

As calculation of these scores is a statistical technicality, two actual examples from the database are presented showing the observed variable values for relative duration, intensity, RPP, and burst absence and the resulting L_{ptk} scores in Table 4-8. Based on the analysis, higher scores indicate more weakening for the /ptk/ group. The range of L_{ptk} scores is -2.79 to 2.55. Record numbers (in parentheses) are for reference only.

Table 4-8.
Observed and latent variable scores for two tokens

Token	/k/ (1)	/t/ (171)
Relative total duration	.12	.38
Intensity ratio	-15.67	-26.70
RPP	.71	.73
Burst absence	1	0
L_{ptk} score	1.09	-1.62
Allophone category	fricative	stop

While large differences in the latent variable score are a natural result of differences in the observed variable scores, it is important to remember that identical L_{ptk} scores do not entail identical scores for the underlying variables. This is easiest to illustrate with examples from the current dataset. As a result of PCA on the set of voiceless singletons, six /k/ tokens were assigned an L_{ptk} score of -.98. Their observed variable scores are, however, not identical, as Table 4-9 shows.

Table 4-9.
Observed scores of tokens with identical L_{ptk} scores

Token	/k/ (1679)	/k/ (1685)	/k/ (450)	/k/ (1681)	/k/ (1039)	/k/ (232)
Relative total duration	.28	.33	.38	.36	.35	.24
Intensity ratio	-13.81	-18.56	-22.72	-13.44	-16.33	-27.95
RPP	.34	.66	.55	.53	.63	.77
Burst absence	0	0	1	0	0	0
L_{ptk} score	-.98	-.98	-.98	-.98	-.98	-.98

Finally, one manual adjustment to the L_{ptk} scores must be made. Of the 637 voiceless oral singleton tokens, 28 were unmeasurable in terms of duration, intensity, and RPP. These 28 tokens (all /k/) were each labeled as 'weak approximant' segments in the qualitative analysis discussed in Chapter 3. Because it was impossible to assign observed variable scores to the individual tokens, SPSS could not calculate L_{ptk} scores for them. They were therefore adjusted by hand, using the conservative approach of assigning each token an L_{ptk} score equal to the maximum score for the entire set of voiceless oral singletons, such that L_{ptk} for each unmeasurable voiceless segment was set to 2.55. A list of the tokens requiring manual adjustments is in Appendix E.

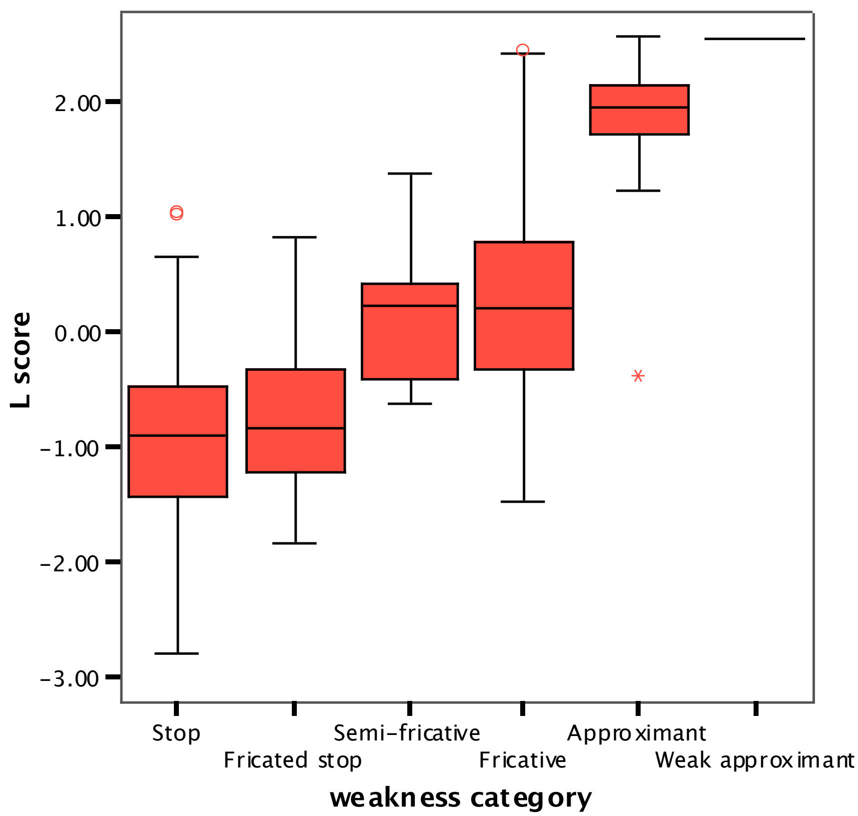
4.3.2 PCA of voiceless oral singletons - results

L_{ptk} component score means for the six allophone categories are in Table 4-10. A boxplot of these means is shown in Figure 4-3. Note the two outliers in the *stop* category and the one extreme in the *approximant* category, marked by º and *, respectively.

Table 4-10.
Mean L_{ptk} Scores by allophone

Allophone	N	Mean L_{ptk} score
Weak approximant	28	2.55
Approximant	28	1.85
Fricative	368	0.30
Semi-fricative	23	0.13
Fricated stop	80	-0.77
Stop	110	-0.94

Figure 4-3.
Boxplot of L_{ptk} Scores by allophone



A statistically significant difference was found among the allophone categories on L_{ptk} scores, F (5, 631) = 168.588, $p < .001$. Games-Howell post hoc tests indicate that there are no significant differences between the semi-fricative/fricative pairs or between the stop/fricated-stop pairs, a finding that is predicted by the relatively high loading of L_{ptk} with the original intensity variable. Recall from Chapter 3 that intensity values for allophone categories predict the following homogeneous subsets, to which we may now add the subset of weak approximant segments.

weak approximant	approximant	fricative semi-fricative	fricated stop stop

Based on these findings, the use of L_{ptk} as a latent determiner of lenition is justified for the set of voiceless oral stops, and will be used in running descriptives and in testing the hypotheses central to this study.

4.3.3 PCA of voiced oral singletons - method

The descriptives discussed in Chapter 3 lead to the conclusion that voicing and intensity are not, in fact, reliable indicators of lenition for voiced oral stops. The only two measured variables that have a relationship to weakening appear to be the following.

- relative total phoneme duration = (constriction duration + VOT duration)/ VCV duration
- release burst absence

As in the case of voiceless stops, weaker segments exhibit a decrease in duration and an increase in burst absence rate.

Using these two input variables, all of the assumptions pass the tests required by PCA. The determinant is .885 – greater than .00001; the KMO measure is an adequate .50; and Bartlett's Test of Sphericity is significant at $p < .001$. There is no other combination of input variables whose assumptions pass these tests, so although the KMO measure (which indicates that a sufficient number of items is predicted by each component) is quite low, PCA was run on the voiced oral singletons using the two input variables noted above. PCA returns one component with an Eigenvalue over 1 (1.339) that accounts for 67% of the variance in the data, as illustrated in the SPSS output in Table 4-11.

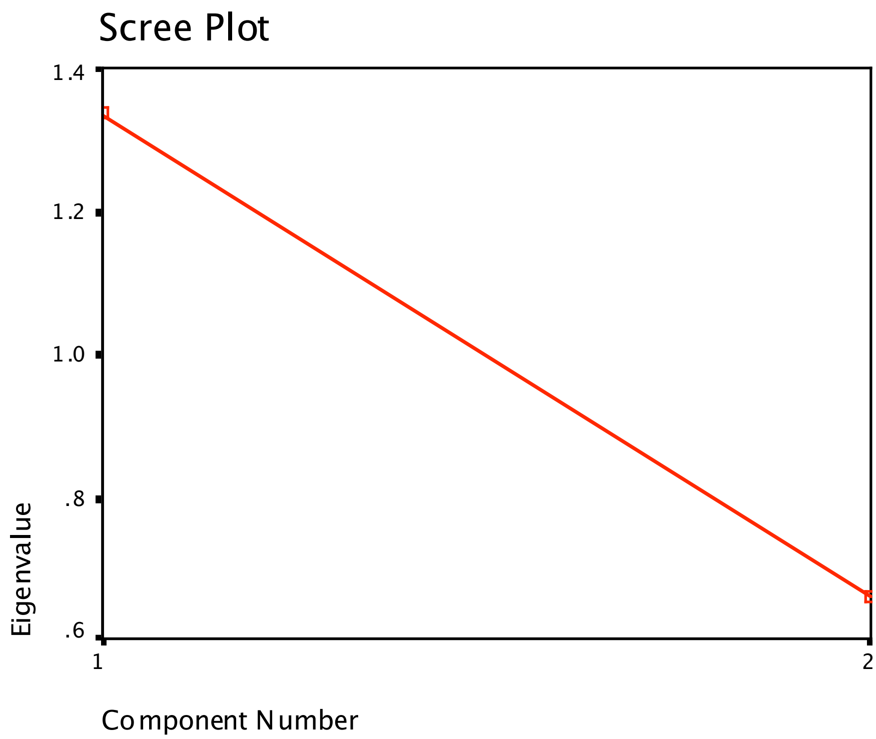
Table 4-11.
Total Variance Explained (voiced oral singletons)

	Initial Eigenvalues		
Component	Total	% of Variance	Cumulative %
1	1.339	66.939	66.939
2	.661	33.061	100.000

Extraction Method: Principal Component Analysis.

The Scree plot for this analysis is uninteresting, given that there are only two components:

Figure 4-4.
Scree plot of components and *eigenvalues* (voiced oral singletons)



Based on the eigenvalues alone, Component 1 was extracted and renamed L_{bdg}. Table 4-12 illustrates how L_{bdg} is defined in terms of the two original observed variables.

Table 4-12.
Component Score Coefficient Matrix for L_{bdg}

	L_{bdg}
Relative total duration	-.611
Burst absence	.611

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Component Scores.

L_{bdg}, as L_{ptk}, is negatively loaded with the original variable of relative total duration and positively loaded with the variable of burst absence, meaning that tokens with lower durations and higher burst absence rates will have higher L_{bdg} scores. Both loadings are quite high.

SPSS saves an L_{bdg} score for each voiced oral singleton token in the database. Table 4-13illustrates the observed variable values and resulting L_{bdg} scores for two example tokens. Higher scores indicate more weakening, and the range of L_{bdg} scores is -2.99 to 1.87.

Table 4-13.
Observed and latent variable scores for two tokens

Token	/b/ (record 5)	/d/ (record 2)
Relative total duration	.13	.16
Burst absence	1	0
L_{bdg} score	1.19	-.31
Allophone category	fricative	stop

As with the set of voiceless segments, a manual adjustment needed to be made for the voiced oral singletons. Of 358 tokens, 18 surfaced as unmeasurable (15 weak approximant, 2 approximants, and 1 fricative), and were each assigned the maximum L_{bdg} score of 1.87 – again, a conservative adjustment.

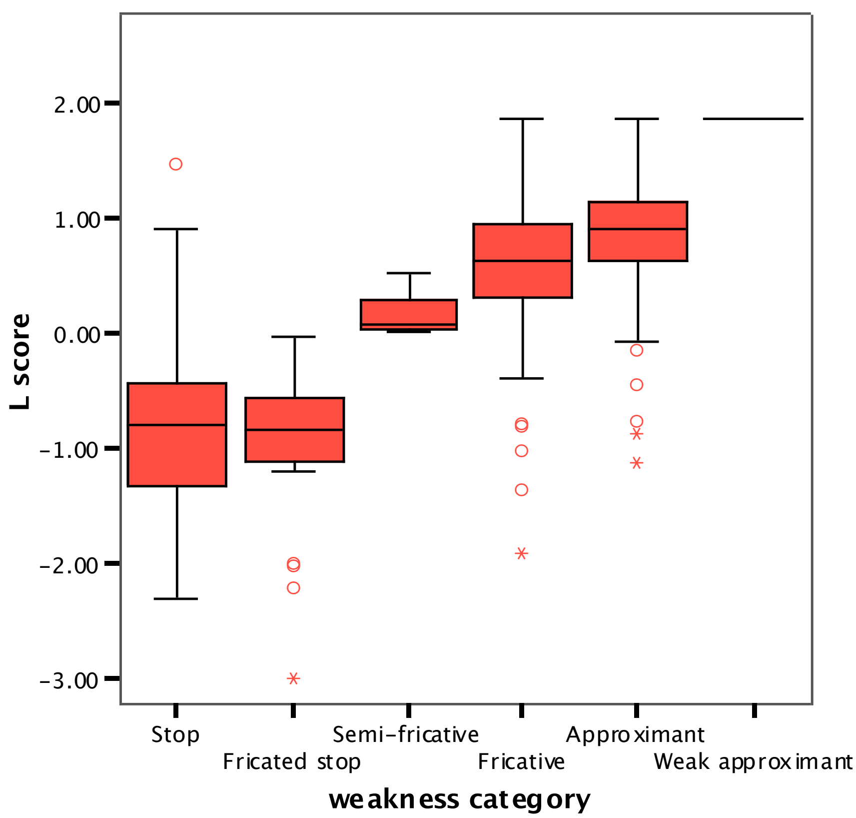
*4.3.4*4.3.4 PCA of voiced oral singletons - results

Descriptives run using the L_{bdg} component scores as dependent variables and allophone categories as independent variables are in Table 4-14. A boxplot of these means is shown in Figure 4-5, including 11 outliers (°) and four extremes (*).

Table 4-14.
Mean L_{bdg} scores by allophone

Allophone	N	Mean L_{bdg} score
Weak approximant	15	1.87
Approximant	110	.84
Fricative	82	.55
Semi-fricative	3	.21
Fricated stop	30	-.95
Stop	118	-.89

Figure 4-5.
Boxplot of L_{bdg} scores by allophone



The effect of allophone category on L_{bdg} score is significant, $F(5, 352) = 152.90$, $p < .000$. Games-Howell post hoc tests indicate significant differences between pairings of approximants, fricatives, and stops/fricated-stops. With respect to semi-fricatives, N (at 3) is low enough to justify its inclusion in the fricative category. The results of PCA on voiced oral stops effectively indicate the following homogeneous subsets, identical to those for voiceless stops.

weak approximant	approximant	fricative semi-fricative	fricated stop stop

4.3.5 Aggregating the lenition scores

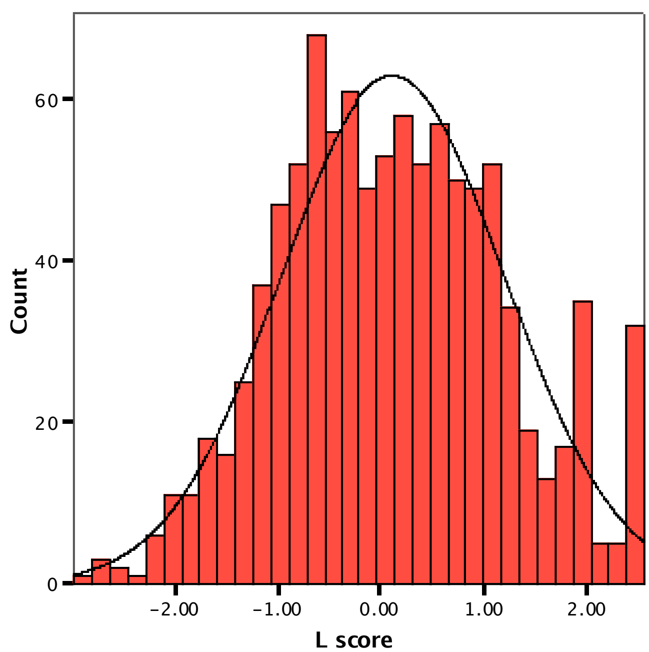
Although it was necessary to perform PCA independently on the sets of voiceless and voiced oral singletons because of differences in the adequacy of lenition indicators, we may now combine the sets. This is because SPSS assigns component scores to each token in the form of standard scores (also known as *Z*-scores, although there is a slight technical difference depending on the normality of the original variables[40]). A standard score is representative not of a raw, absolute measurement, but instead of the distance from the mean in terms of *Z* standard deviations[41]. A standard score of 2, therefore, represents an actual score that is 2 standard deviations above the mean, or in the 95th percentile of actual scores. The mean of any set of standard scores is always equal to zero, since the mean is zero standard deviations away from itself. The standard deviation of these scores is also equal to zero. Standard scores are very

[40] Per Fox (1998: 91), "*Z*-scores are transformations of scores only on normally distributed variables, whereas standard scores are transformations of *any* variable, even ones not normally distributed." Fox mentions that the two terms are often used interchangeably.

[41] The mean of any set of z-scores is always equal to zero, since the mean is zero standard deviations away from itself. The standard deviation of z-scores is also zero.

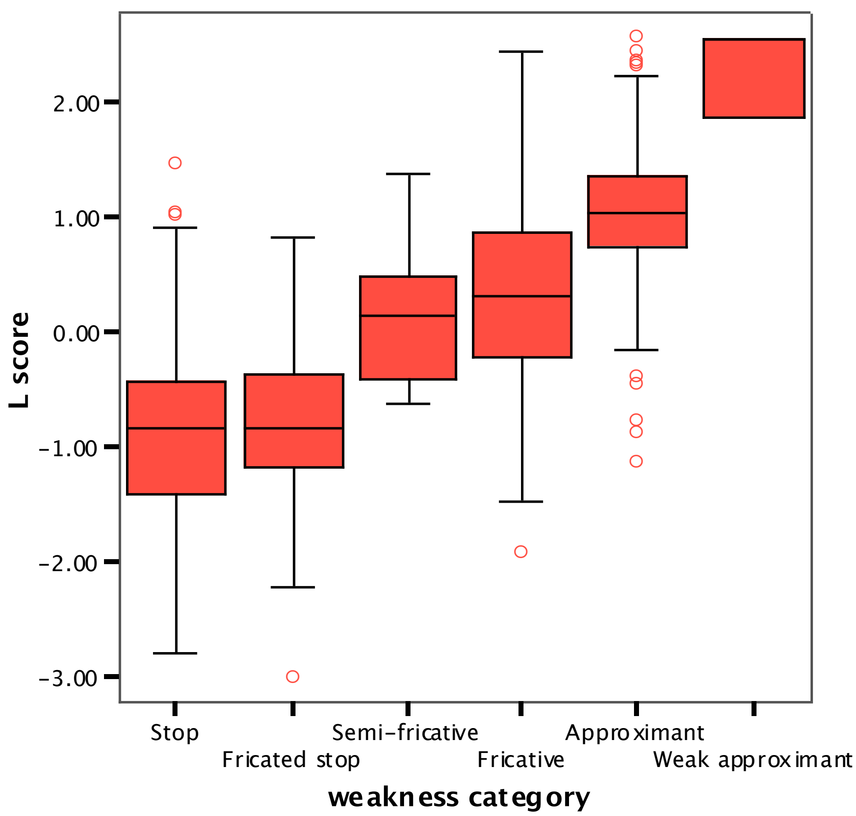
useful for making comparisons between sets of variables that have different means and standard deviations, as they equalize these differences. This is of particular benefit to the case at hand, as even though the raw L_{ptk} scores and L_{bdg} scores were computed independently, the process of standardization puts them on the same scale, and the scores will henceforth be referred to as L, which is normally-distributed as shown in Figure 4-6 below.

Figure 4-6.
Histogram of L scores with normal curve



We can now examine the L scores by allophone category and in doing so, we see a strong correlation of L with observed weakness for the combined group of oral singletons ($N = 995$)[42]. The boxplot in Figure 4-7 illustrates this.

Figure 4-7.
Boxplot of L scores by allophone



[42] Of the original 1,020 singleton stops, relative periodicity power was unable to be calculated for 25 of them (due to short durations). These 25 stops were not assigned L scores and are hereafter excluded from the analysis.

Although there are a few outliers (13 in all), the plot in Figure 4-7 clearly shows that surface realizations of oral singletons steadily increase in L as they weaken. The mean L scores for each allophone category are in Table 4-15.

Table 4-15.
Mean L scores by allophone (all oral singletons)

Allophone	N	Mean L score
Weak approximant	43	2.31
Approximant	138	1.05
Fricative	450	.35
Semi-fricative	26	.14
Fricated stop	110	-.82
Stop	228	-.91

Although we examine the entire set of oral singletons as a group, using the standard scores, there are obvious differences in the behavior of voiceless and voiced segments with respect to subject and place of articulation effects. Therefore, the following sections present descriptive data separately for each voicing category.

4.4 Descriptive statistics of voiceless oral singletons

The statistics presented in this and the following section reflect the same observations discussed in the previous chapter, with the key difference being that here the results are quantitative.

4.4.1 Lenition scores by subject and gender

Standardized L scores range from -2.99 to 2.55 for the 637 voiceless oral singletons. Recall that higher L scores are indicative of more lenition.

The minimum, maximum, mean L scores, and their standard deviations for each subject are in Table 4-16[43]. Ns for these subjects differ slightly due to disfluent segments that were eliminated from the analysis.

Table 4-16.
Descriptive statistics of L scores by subject (voiceless oral singletons)

Subject	N	Min	Max	Mean	Std. Dev.
M1	108	-1.59	2.55	.82	1.12
F1	107	-1.94	2.55	.47	1.35
F3	103	-1.80	2.00	.43	.85
F2	111	-1.64	1.84	.05	.75
M3	104	-2.70	1.40	-.53	.72
M2	104	-2.79	1.34	-.59	.93

Based on these data, the subjects exhibiting the most lenition of voiceless stops are M1, F1, and F3. Subjects M2 and M3 lenite the least, and subject F2 lenites moderately. We generally see the same behavior using the L scores as we saw in the allophone analysis in Chapter 3, in which it was noted that M1 and F1 lenite heavily, F2 and F3 moderately, and M2 and M3 lightly. All subjects exhibit a fair amount of variation, but the standard deviations of L scores indicate that the behavior of some subjects is more variable than others.

Gender differences are evident in the lenition scores, indicating a much higher incidence of lenition in the female subjects, but it is not possible to extend this observation to the general population, given both the small *N* and the observation that two of the lightest leniters are male.

[43] Note that although standard scores have a mean and standard deviation of zero for the entire group of subjects and oral singletons, they will necessarily differ when subjects and segments are analyzed individually.

Table 4-17.
Descriptive statistics of L scores by gender (voiceless oral singletons)

Subject	N	Min	Max	Mean	Std. Dev.
Female	321	-1.94	2.55	.31	1.04
Male	316	-2.79	2.55	-.09	1.15

4.4.2 Lenition scores by phoneme

The difference in behavior among the voiceless oral stops is obvious, and fairly consistent among the six subjects. L score descriptives are in Table 4-18.

Table 4-18.
Descriptive statistics of L scores by phoneme (voiceless oral singletons)

Phoneme	N	Min	Max	Mean	Std. Dev.
/k/	227	-1.89	2.55	.60	1.28
/p/	185	-2.57	2.00	-.04	.89
/t/	225	-2.79	1.89	-.26	.90

Table 4-18 shows that /k/ has the highest average L scores and /t/ the lowest, while /p/ falls somewhere in between, consistent with the findings based on allophonic variation. This hierarchy (k > p > t) is observed in three of the six subjects, M1, F1, and F3, but the other three subjects exhibit different patterns: for F2 and M3, the lenition scores are ranked in the order of (p > k > t) and M2's ranking is (k > t > p). Note that /k/ is never last in these hierarchies, and that /t/ is last in all but one of the six, indicating a general tendency among all the subjects to lenite /k/ the most, and /t/ the least.

Illustrations of L score distributions by voiceless phoneme (for all subjects) are in Figure 4-8 through Figure 4-10.

Figure 4-8.
Histogram of L scores for phoneme /k/

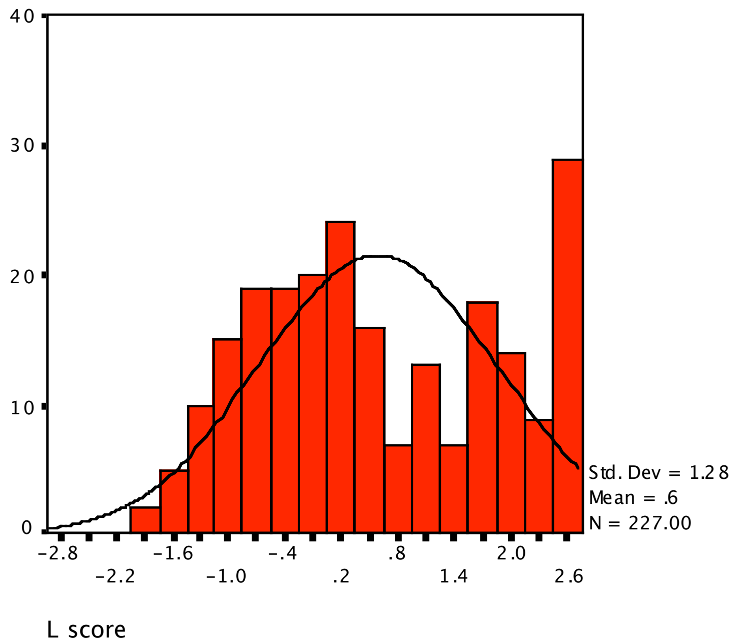


Figure 4-9.
Histogram of L scores for phoneme /p/

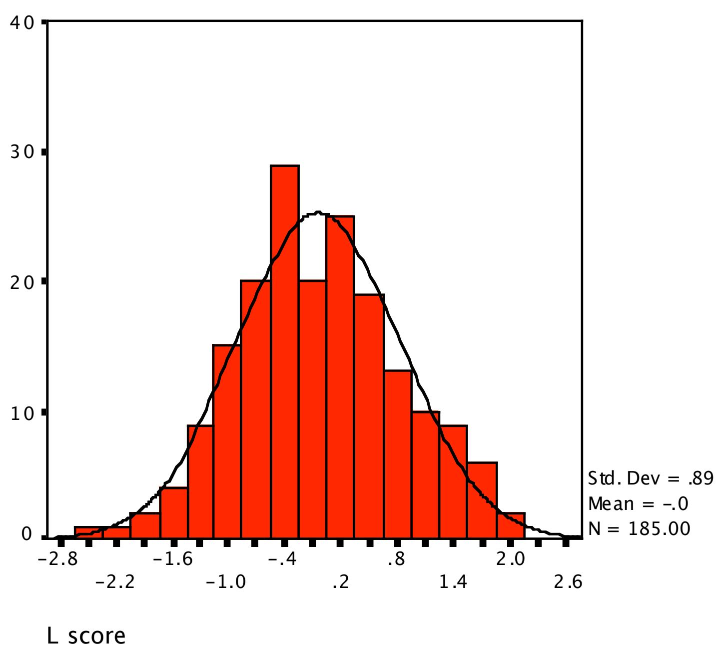
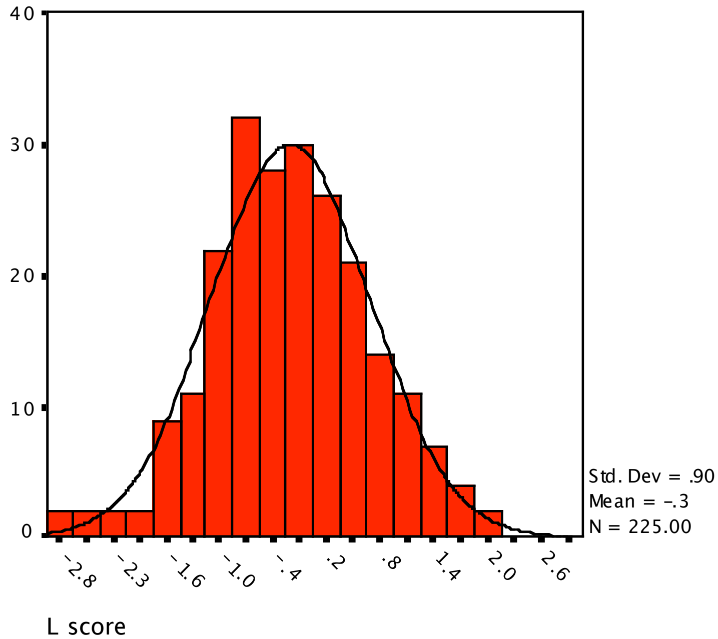


Figure 4-10.
Histogram of L scores for phoneme /t/



As these histograms indicate, L scores for /p/ and /t/ are relatively normally distributed, while those for /k/ exhibit a much greater level of variance and are verging on the point of bimodality. This more radical behavior noted for /k/ is likely due to the fact that of the three voiceless oral singletons, only /k/ surfaces as a weak approximant. Considering the data independently of weak approximant, however, a normal distribution is approximated.

4.5 Descriptive statistics of voiced oral singletons

4.5.1 Lenition scores by subject and gender

For the set of 358 voiced oral singletons in this dataset, standardized L scores range from -2.99 to 1.87. Again, higher scores indicate more lenition. Descriptives of L scores by individual subject are in Table 4-19.

Table 4-19.
Descriptive statistics of L scores by subject (voiced oral singletons)

Subject	N	Min	Max	Mean	Std. Dev.
M1	60	-1.13	1.87	.68	.70
F1	58	-1.92	1.87	.47	1.00
F2	60	-1.78	1.32	.17	.89
M2	60	-2.28	1.87	-.05	1.21
F3	60	-2.99	1.87	-.12	1.18
M3	60	-2.10	1.47	-.58	.81

M1 and F2 lenite their voiced segments to the greatest extent, an observation consistent with the behavior of voiceless tokens for these subjects. M3's voiced segments lenite the least, also consistent with his lenition of voiceless segments. F2 continues to be a moderate leniter for this category of tokens, but F3 and M2 seem to treat their voiced and voiceless segments differently. While F3 was a heavy leniter of voiceless stops, she only moderately weakens the voiced items. M2, observed as a light leniter of voiceless tokens, tends to weaken voiced segments to a greater extent. For clarity's sake, the subjects' lenition tendencies for both voiced and voiceless oral singletons are presented in Table 4-20. Light leniters are those subjects with mean L scores below -.40 (this score indicating a mean that is .4 standard deviations below the overall L mean). Heavy leniters have mean L scores above .40. Moderate leniters' L scores are within .4

standard deviations of the mean.

Table 4-20.
Lenition tendencies of individual subjects

Subject	-voi oral singletons	+voi oral singletons	all oral singletons
M1	High	High	High
F1	High	High	High
F3	High	Moderate	Moderate
F2	Moderate	Moderate	Moderate
M2	Light	Moderate	Moderate/light
M3	Light	Light	Light

Table 4-20 illustrates the same lenition trends among the subjects as the qualitative analysis presented in Chapter 3. With the number of subjects being small, it may not be possible to generalize their behavior to a larger population. Nevertheless, an interesting sociolinguistic observation is worth discussing here. As the subject information in Appendix A shows, there are robust differences among the subjects in terms of educational levels. M1, F1, and M3 have by far the lowest levels of education, and F3 and M2 the highest. Excepting M3, who has the most foreign language exposure of all the subjects (in fact, he is married to a native speaker of Portuguese), there seems to be a correlation between consistently high lenition rates and low educational levels. The two subjects with the equivalent of Master's degrees (F3 and M2) exhibit much more moderate, and variable, lenition behaviors.

As with the set of voiceless segments, it is not possible to generalize about gender effects on lenition, due to the small number of subjects.

4.5.2 Lenition scores by phoneme

For the class of voiced oral singletons, all subjects lenite velar segments to a greater extent than labials or dentals. Five of the subjects exhibit the same lenition order (g > d > b), while for M1 the order is g > d > b. While velars in both the voiceless and voiced sets consistently lenite the most, the dentals and labials in these sets behave differently: voiceless labials lenite more than voiceless dentals, but voiced dentals lenite more than voiceless labials. This inconsistency in place of articulation effects on lenition warrants further discussion, and will be treated in Chapter 6. Lenition scores for voiced phonemes are in Table 4-21.

Table 4-21.
Descriptive statistics of L scores by phoneme (voiced oral singletons)

Phoneme	N	Min	Max	Mean	Std. Dev.
/g/	108	-1.39	1.87	.72	.76
/d/	126	-1.24	1.87	.14	.81
/b/	124	-2.99	1.87	-.50	1.17

We see the same maximum L scores for each voiced phoneme – this is due to the manual corrections made for unmeasurable segments. Although among the voiceless segments /k/ was the only token that surfaced as unmeasurable, /b/, /d/, and /g/ each exhibit some amount of extreme weakening. Appendix E details the 18 unmeasurable voiced oral singletons, which consist of nine /g/ tokens, four /d/ tokens, and five /b/ tokens.

The histograms of L score distributions by voiced phoneme (for all subjects) are in Figure 4-11 through Figure 4-13 and illustrate the clear differences in lenition behavior of the three consonants under investigation.

Figure 4-11.
Histogram of L scores for phoneme /b/

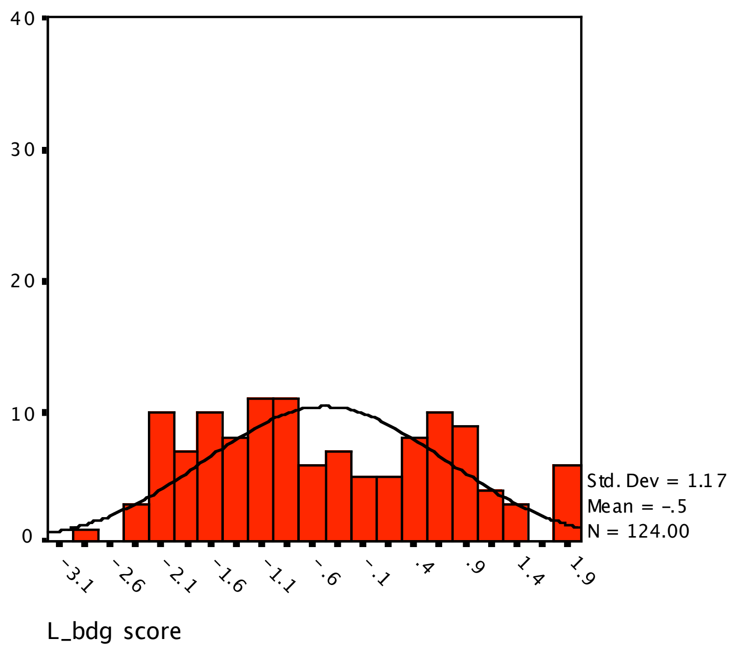


Figure 4-12.
Histogram of L scores for phoneme /d/

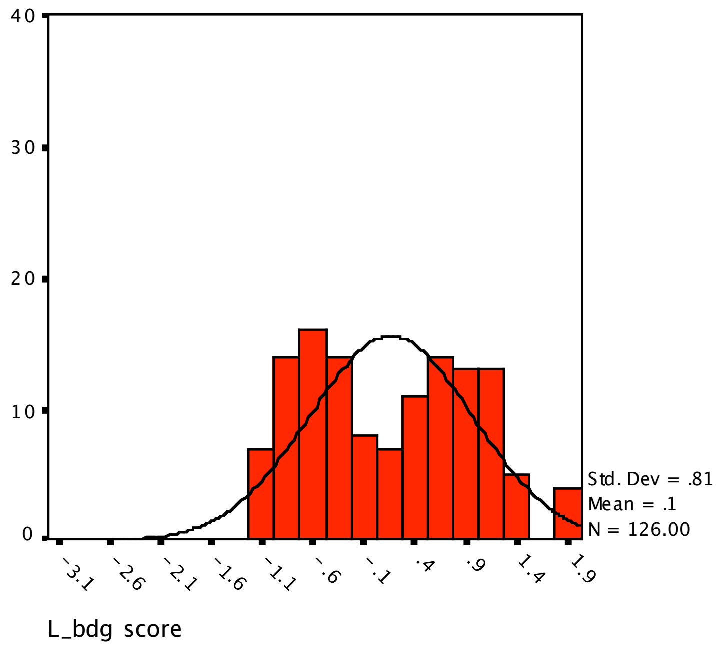
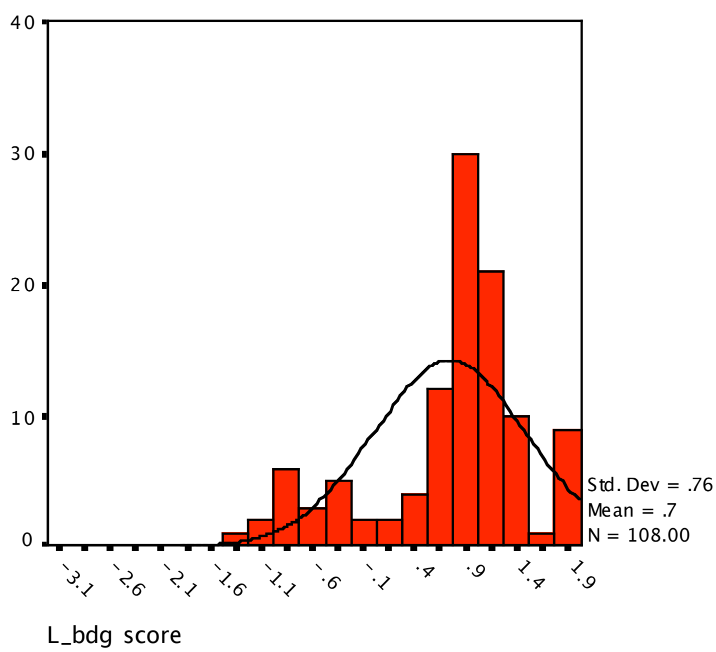


Figure 4-13.
Histogram of L scores for phoneme /g/



Unlike the scores for voiceless segments, which were normally distributed for /p/ and /t/, the lenition scores for voiced segments are not at all normal – scores for both /b/ and /d/ border on bimodality. The fact that the central portion of the histograms is actually lower than the edges suggests that these two segments seem to either lenite very weakly (or not at all) or lenite very heavily, with little moderate lenition. The histogram of scores for the voiced velar /g/ might also be said to be bimodal, with a strong skewing towards heavy lenition.

4.6 Descriptive statistics of oral singletons by subject and phoneme

At this point it might be interesting to look at a narrower view of lenition within subjects in order to gauge lenition patterns of each individual. Table 4-22, therefore, shows the mean L score of each phoneme by subject, and Table 4-23 shows the ranking of phonemes from highest mean L score to lowest. Subjects are ordered according to their overall lenition behaviors (high to light).

Table 4-22.
Mean L scores by subject and phoneme

	M1		F1		F3		F2		M2		M3	
	N	mean L	N	mean L	N	mean L	N	mean L	N	mean L	N	mean L
/p/	32	.58	30	-.19	29	.40	33	.14	31	-.85	30	-.32
/t/	37	.02	39	-.58	37	.30	39	-.01	35	-.51	38	-.75
/k/	39	1.78	38	2.06	37	.59	39	.04	38	-.46	36	-.48
/b/	21	.66	19	.01	21	-1.12	21	-.20	21	-1.24	21	-1.06
/d/	21	.58	21	.45	21	-.14	21	.11	21	.35	21	-.50
/g/	18	.84	18	.96	18	1.08	18	.67	18	.87	18	-.11

Table 4-23.
Ranking of L scores by subject (high-to-low)

Subject	Ranking
M1	k >> g >> b >> p >> d >> t
F1	k >> g >> d >> b >> p >> t
F3	g >> k >> p >> t >> d >> b
F2	g >> p >> d >> k >> t >> b
M2	g >> d >> k >> t >> p >> b
M3	g >> p >> k >> d >> t >> b

The lenition patterns are not consistent across subjects, although the velars /k/ and /g/ are consistently highly ranked, while /b/ and /t/ are normally ranked at the bottom of each subject's hierarchy. Two facts work against elaborating on the significance of this narrow view of lenition. First, as the datafile is split into a larger number of groups, the Ns in each category are necessarily reduced. Second, Principal Components Analysis was run using the entire subject pool, so lenition factor scores were not calculated within each subject. Therefore, a subject-specific analysis of lenition *a posteriori* to the calculation of lenition scores must be viewed with caution.

With this explication of Principal Components Analysis, the extraction of L scores for the oral singletons in the dataset, and a descriptive analysis of oral singleton lenition, the hypotheses that form the theoretical core of this dissertation may be tested quantitatively.

5 HYPOTHESIS TESTING AND RESULTS

This chapter presents the outcome of testing the six hypotheses described in Chapter 2. They are repeated here.

H1: Velar consonants will lenite more than labials or dentals.

H2: Consonants in high frequency tokens will lenite more than consonants in low frequency tokens.

H3: Word-internal consonants will lenite more than items at word edges.

H4: Word-internal consonants with stress on the left will lenite more than word-internal items with stress on the right. (In other words, foot-medial consonants will lenite more than foot-initial consonants.)

H5: Consonants flanked by back vowels will lenite more than consonants flanked by front vowels.

H6: Geminate consonants will lenite to long fricatives.

All hypotheses with the exception of H6[44] will be tested using the factor scores derived from the Principal Components Analysis discussed in the previous chapter. The important underlying assumption is that the factor scores (L) are reliable indicators of weakening as described in Chapter 4.

Testing of H2, H3, H4, and H5 is carried out on individual phonemes in order to pre-empt any bias due to uneven distribution of phonemes in terms of the independent variables. A premises-check of these distributions indicates that the six phonemes /p/, /t/, /k/, /b/, /d/, /g/ are not necessarily represented evenly in the dataset in terms of frequency category, prosodic domain, stress position, and V1/V2 backness. Higher

[44] Because of the lower Ns for geminate segments in this study, Principal Components Analysis has not been used to derive factor scores for these segments.

representation of a heavily lenited phoneme, such as /k/, in the word-internal prosodic category, therefore, is likely to cause a Type I error – we would risk rejecting $H4_0$ when this null hypothesis might actually be true. Furthermore, assessing the effects of independent variables on the entire group of six phonemes fails to shed any light on whether certain segments are more or less affected by the independent factors. The minimum N of testable tokens when the hypotheses are assessed by individual phoneme is 108.

5.1 Outcome of hypotheses testing

5.1.1 H1: Place of articulation effects on lenition

Mean L scores for labials are -.223, for dentals -.113, and .638 for velars. Testing H1 on the set of all oral singletons, a statistically significant difference in L is found among the three places of articulation (labial, dental, and velar), $F(2, 992)=69.365$, $p=.000$. The ANOVA of L scores by place of articulation is in Table 5-1.

Table 5-1.
ANOVA: Dependent Variable = place of articulation

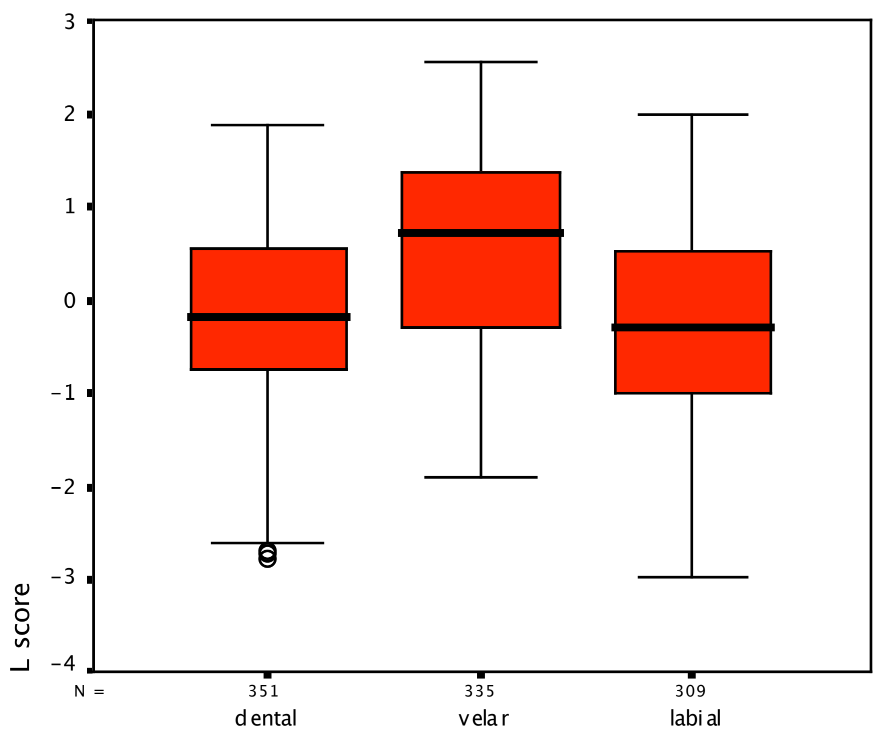
Source	df	F	Sig.
Corrected Model	2	69.365	.000
Intercept	1	9.604	.002
PLACE	2	69.365	.000
Error	992		
Total	995		
Corrected Total	994		

Games-Howell post-hoc tests show significant mean differences in L between the velar group and both the labial ($p=.000$) and the dental ($p=.000$) groups, but not between the labial and dental groups (p=.310). The boxplots in Figure 5-1 illustrate this tendency clearly.

Table 5-2.
Post Hoc: Independent Variable = place of articulation (Games-Howell)

(I) Place	(J) Place	Mean difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Dental	Velar	-.7501	.07796	.000	-.9333	-.5670
	Labial	.1105	.07559	.310	-.0671	.2881
Velar	Dental	.7501	.07796	.000	.5670	.9333
	Labial	.8606	.08562	.000	.6595	1.0618
Labial	Dental	-.1105	.07559	.310	-.2881	.0671
	Velar	-.8606	.08562	.000	-1.0618	-.6595

Figure 5-1.
Boxplot of L scores by place of articulation



They also illustrate a lack of hierarchical lenition effects throughout the natural class of oral stop consonants. As expected, the quantitative assessment of H1 yields exactly the same results as the qualitative (allophonic) analysis undertaken in Chapter 3, and contradicts the attested asymmetry in *Gorgia* effects reported by Giannelli and Savoia (1978:43), Bafile (1997:28), Marotta (2001:31), and Sorianello (2001:82). Each of these authors has claimed a significant 3-point hierarchy, where velars lenite more than dentals, which in turn lenite more than labials. Chapter 3 illustrated that such a hierarchy is found in the subset of voiced oral singletons /b/, /d/, and /g/, but not in the voiceless subset, where the hierarchy appears to be velar > labial > dental. The mean L scores in Table 5-3 show that an identical pattern surfaces when the data are analyzed quantitatively. ANOVAs run on the voiced and voiceless subsets show significant place effects: $F(2, 355)=49.015$, $p=.000$ for voiced segments; $F(2, 634)=40.350$, $p=.000$ for voiceless segments. Post hoc tests indicate that the voiced segments /b/, /d/, and /g/ differ significantly from one another ($p=.000$), as do the voiceless segments /p/, /t/, and /k/ (although $p=.038$ for the /p/-/t/ pair).

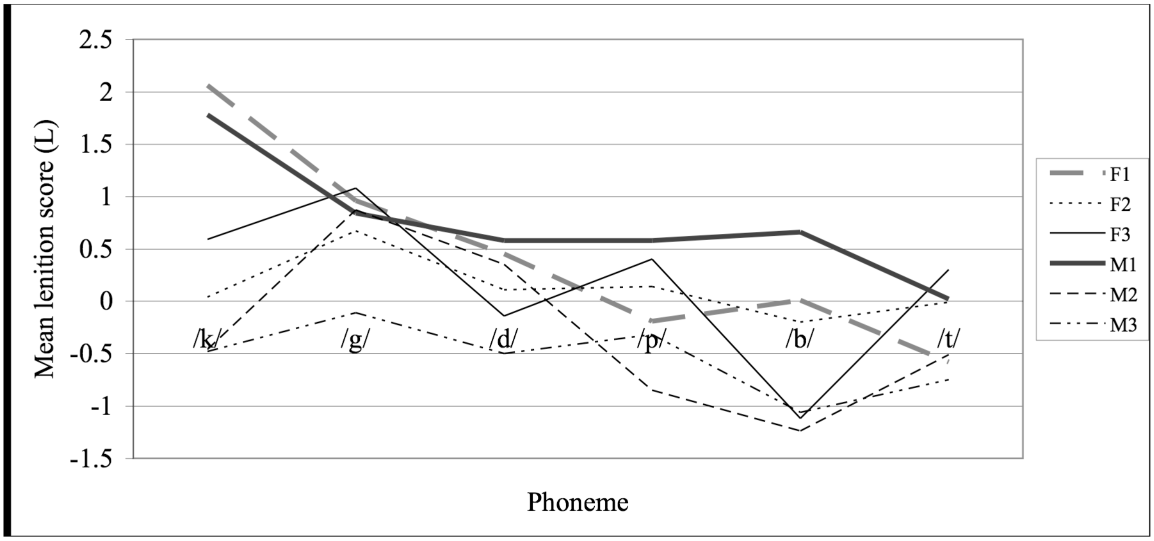
Table 5-3.
Mean L scores by place of articulation (by underlying voicing)

	L	
Place	+voi	-voi
Labial	-.5001	-.0375
Dental	.1428	-.2557
Velar	.7191	.5986

On the basis of the statistics, the hypothesis H1 stating that velars will lenite more than labials or dentals is confirmed, and claims regarding other place of articulation effects are called into question. Some variability, however, is found among subjects with respect to place of articulation. Figure 5-2 (graphed from Table 4-22 in the previous chapter[45]) illustrates that only two of the subjects, M1 and F1 (represented by the thicker lines), show higher lenition of /k/ than of any other segment. The other four subjects show a preference for leniting /g/, and three of these rank /k/ no higher than third. An additional pattern emerges, however, in which M1 and F1 appear both extremely similar to one another and markedly different from the other subjects in terms of their lenition hierarchies. This pattern is of interest when we consider the general educational levels, social status in terms of employment experience, and exposure to non-Florentine culture and language. These details are found in the subject profiles in Appendix A, and indicate a rather different social profile for M1 and F1 than for the other four subjects.

[45] Thanks are due to Robin Dodsworth (personal communication) for her assistance in this graphic representation of the intra-subject lenition patterns.

Figure 5-2.
Inter-subject variation in segment lenition



Although the place of articulation effects appear generally robust, the facts illustrated in the graph above and the unique subject characteristics of M1 and F1 cannot be ignored and will be discussed further in the subsequent chapter.

5.1.2 H2: Lexical frequency effects on lenition

Frequency of word tokens has little effect on the lenition scores in this dataset. Table 5-4 shows that segments in high-frequency lexical items do not have significantly higher L scores, with the exception of the voiceless velar stop /k/ (p=.005). The hypothesis H2 therefore, is confirmed for /k/, but not for any other phoneme.[46]

[46] In fact, the directionality of frequency effects for /t/ are exactly the opposite – for this phoneme, low-frequency items have significantly higher L scores (p=.03).

Table 5-4.
T-Test: Independent Variable = frequency category

Phoneme	Freq. category	Mean freq. in dataset	N	M	SD	t	df	Sig (1-tailed)
/b/		276				-.47	122	.32
	Low		70	-.544	1.23			
	High		54	-.444	1.11			
/d/		171				-.80	124	.21
	Low		54	.076	.772			
	High		72	.193	.832			
/g/		98				-1.32	106	.095
	Low		54	.623	.798			
	High		54	.815	.710			
/p/		50				-.34	183	.37
	Low		137	-.051	.891			
	High		48	.000	.898			
/t/		58				1.88	223	.97
	Low		156	-.182	.850			
	High		69	-.424	.978			
/k/		78				-2.63	225	.009
	Low		141	.427	1.300			
	High		86	.881	1.192			

It makes sense at this point to look at phoneme frequencies in Italian in order to establish whether high occurrence of a phoneme is a plausible correlate of lenition. The data in Table 5-5 are a summary of raw data extracted[47] from the AVIP (Archivio delle

[47] Many thanks to Caren Brinckmann at Saarland University's Institute of Phonetics for her assistance in extracting the relevant raw data for me. Summaries and estimates of phoneme frequencies, and any errors of course, are entirely my own.

Varietà di Italiano Parlato) corpus, which contains approximately 3.5 hours of speech and includes transcriptions and phonemic labeling for approximately 10% of the data in the corpus.

Table 5-5.
Phoneme frequencies (extracted from AVIP corpus)

Phoneme	Total Count (of 24,232)	% of Total	# per 1000
/t/	1077	0.04	44.45
/d/	895	0.04	36.93
/k/	643	0.03	26.54
/p/	641	0.03	26.45
/b/	253	0.01	10.44
/g/	225	0.01	9.29

Phoneme frequency, as word frequency, appears to have no obvious effect on lenition, as a comparison of phoneme rankings in Table 5-5 and Table 5-6 indicates. The lowest-frequency phoneme, /g/, has the highest L score, while the highest frequency phoneme, /t/, has an L score near the bottom of the ranking.

Table 5-6.
Descriptive statistics of L scores by phoneme (ordered by L score)

Phoneme	N	Mean
/g/	108	.72
/k/	227	.60
/d/	126	.14
/p/	185	-.04
/t/	225	-.26
/b/	124	-.50

It does not appear to be the case, therefore, that some interaction of phoneme and word frequencies is a contributor to weakening, and we are simply left with one statistically significant fact: higher lexical frequency at the word level correlates with higher rates of lenition for one, and only one, phoneme: the voiceless velar stop /k/.

Lenition of one other phoneme, however, may be affected by lexical frequency. Although t-test results are not statistically significant (p=.095), the significance levels for frequency effects on L scores are *relatively* high for the other velar phoneme /g/. Ranking the oral stop phonemes by the extent to which lexical frequency corresponds with lenition, then, presents us with a more interesting picture: lenition of the two velar consonants is more likely to be tied to frequency than is lenition of other consonants., an outcome that is very much in line with the allophonic observations in Chapter 3.

5.1.3 H3: Prosodic environment effects on lenition

Prosodic environment of tokens has little effect on the lenition scores in this dataset. Significant trends are only seen for /p/ and /t/, as Table 5-7 shows.

Table 5-7.
T-Test: Independent Variable = prosodic environment

Phoneme	Pros. Environ.	N	M	SD	t	df	Sig (1-tailed)
/b/					1.170	122	.122
	Word-internal	71	-.394	1.198			
	Word-boundary	53	-.643	1.138			
/d/					.190	124	.425
	Word-internal	90	.152	.828			
	Word-boundary	36	.121	.757			
/g/					-1.138	106	.871
	Word-internal	72	.661	.746			
	Word-boundary	36	.836	.779			
/p/					3.422	183	.001
	Word-internal	135	.095	.880			
	Word-boundary	50	-.395	.825			
/t/					4.362	223	.000
	Word-internal	157	-.091	.815			
	Word-boundary	68	-.637	.962			
/k/					-.458	225	.677
	Word-internal	141	.568	1.240			
	Word-boundary	86	.648	1.340			

Although the t-test results are not significant for any other phonemes with respect to the effect of word-internal status on lenition, it is interesting to note that /k/ and /g/ seem to be the least affected segments. A look at the mean L scores in Table 5-7 reveals that of the six phonemes under investigation, only the two velars lenite more in word-boundary environments than in word-internal environments – all other segments lenite more when they are internal to words. (We can also see this opposite trend by looking at *t* for each consonant – only /k/ and /g/ have negative *t* values).

At this point it might be helpful to re-address the labels "word-internal" and "word-boundary." These descriptors were initially chosen because their link to frequency effects was transparent: a given single word by its nature should occur more frequently than that word preceded by a determiner, modifier, or quantifier. It was therefore predicted that just as lexical frequency would positively affect lenition, word-internal status would induce more lenition, all other things being equal. Taken together, the t-test outcomes in Table 5-4 (frequency effects) and Table 5-7 (prosodic effects) do not support this prediction – the very segments whose lenition is most positively affected by higher frequency are the segments whose lenition is *least* positively affected by word-internal status, and vice-versa.

There is another way to look at the situation. Word-boundary items appear at word edges, and may exhibit different behaviors in the domain of sound change than their word-internal counterparts (Broselow 2003). Given the special status of /k/ and /g/ with respect to the first two hypotheses tested, and the fact that the lenition of these two segments is less impeded at word edges than the lenition of other segments is, it seems reasonable to focus on the outcome of H3 as indicating some resistance to lenition in prosodically strong positions on the part of non-velar segments. In other words, /k/ and /g/ lenite most evenly across the board, while /p/ and /t/ lenite more word-internally and less at word-edges. This prosodic effect, although not significant, indicates a potentially greater role played by phonological factors in the lenition of non-velars.

5.1.4 H4: Stress position effects on lenition

Left-stress, or foot-mediality, affects only certain segments in this dataset significantly. Table 5-8 illustrates the effects of left-stress on greater lenition of the voiced labial /b/ (*p*=.004) and of the voiceless dental /t/ (*p*=.000).

Table 5-8.
T-Test: Independent Variable = stress position

Phoneme	Stress Position	N	M	SD	t	df	Sig (1-tailed)
/b/					2.746	69	.004
	Left	36	-.025	1.123			
	Right	35	-.772	1.169			
/d/					-.872	88	.808
	Left	18	-.001	.795			
	Right	72	.190	.838			
/g/					-.952	70	.828
	Left	36	.577	.652			
	Right	36	.744	.830			
/p/					1.163	133	.124
	Left	102	.1450	.925			
	Right	33	-.060	.714			
/t/					4.523	155	.000
	Left	122	.058	.794			
	Right	35	-.609	.672			
/k/					-1.899	139	.970
	Left	88	.416	1.285			
	Right	53	.821	1.128			

The hypothesis stating that foot-medial segments will lenite more is confirmed for the two segments in this dataset that appear least susceptible to lenition, /b/ and /t/. There is a non-significant trend that the heaviest leniters are least affected by this prosodically weak position. As with the prosodic effects in the previous section, these patterns indicate that the phonological construct of the foot is involved to a greater extent in the weakening of certain segments.

<u>*5.1.5 H5: Vowel effects on lenition*</u>

The data do not support that vowel-backness (of both V1 and V2) has a positive effect on lenition. To test this, descriptive statistics were run on mean L scores for three subsets of the dataset: all oral singletons, voiceless oral singletons, and voiced oral singletons. In each case, the highest L scores occur when V2 is [+back], although when V2 backness is held constant, we find that more lenition occurs in segments preceded by a [-back] vowel. In fact, the greatest mean L scores occur where V1 is [-back] and V2 is [+back], as Table 5-9 through Table 5-11 illustrate.

Table 5-9.
Mean L scores by vowel backness (all oral singletons)

V1	V2	Mean L
[-back]	[-back]	-.018
[-back]	[+back]	.385
[+back]	[-back]	-.373
[+back]	[+back]	.188

Table 5-10.
Mean L scores by vowel backness (voiceless oral singletons)

V1	V2	Mean L
[-back]	[-back]	-.016
[-back]	[+back]	.314
[+back]	[-back]	-.362
[+back]	[+back]	.184

Table 5-11.
Mean L scores by vowel backness (voiced oral singletons)

V1	V2	Mean L
[-back]	[-back]	-.022
[-back]	[+back]	.553
[+back]	[-back]	-.383
[+back]	[+back]	.196

V1 and V2 backness, on their own, however, have some effects on lenition as shown in the t-tests below.

Table 5-12.
T-Test: Independent Variable = V1 backness

Phoneme	V1 backness	N	M	SD	t	df	Sig (1-tailed)
/b/					-.615	122	
	[-back]	18	-.658	1.30			.730
	[+back]	35	-.473	1.157			.270
/d/					-.625	124	
	[-back]	54	.091	.833			.733
	[+back]	72	.182	.788			.267
/g/					1.881	106	
	[-back]	54	.855	.565			.031
	[+back]	54	.584	.897			.969
/p/					-.061	183	
	[-back]	102	-.041	.906			.525
	[+back]	83	-.033	.876			.476
/t/					-.626	223	
	[-back]	89	-.302	.883			.734
	[+back]	136	-.225	.907			.266
/k/					2.208	225	
	[-back]	105	.798	1.196			.014
	[+back]	122	.427	1.132			.986

Table 5-13.
T-Test: Independent Variable = V2 backness

Phoneme	V2 backness	N	M	SD	t	df	Sig (1-tailed)
/b/					-1.670	122	
	[-back]	87	-.614	1.108			.951
	[+back]	37	-.232	1.295			.049
/d/					2.466	124	
	[-back]	54	.343	.854			.008
	[+back]	72	-.008	.738			.993
/g/[48]					--	--	
	[-back]	--	--	--			--
	[+back]	--	--	--			--
/p/					.964	183	
	[-back]	101	.020	.814			.168
	[+back]	84	-.107	.975			.879
/t/					-2.445	223	
	[-back]	85	-.441	.977			.993
	[+back]	140	-.143	.827			.007
/k/					-1.173	225	
	[-back]	17	.250	1.410			.879
	[+back]	210	.627	1.264			.121

In the case of the heaviest leniters, /g/ and /k/, L scores are significantly higher when V1 is [-back]. For the segments exhibiting the least lenition, /t/ and /b/, on the other hand, L scores are significantly higher when V2 is [+back]. The voiced dental /d/

[48] Statistics on V2 backness cannot be computed for /g/ as there are no VgV sequences in the dataset where V2 is [-back].

lenites more when V2 is [-back], and no significant relationship between vowel backness and lenition is found for /p.

The null hypothesis H5 is confidently rejected. Weakening of segments, however, is affected differently by V1 and V2 backness.

As the hypothesis testing on oral singletons is concluded, it is worth mentioning that very few significant interactions of the independent variables of frequency, prosodic domain, stress position and vowel backness are observed, and such interactions, when present, only affect /b/, /d/, and /p/.

Where /b/ is concerned, the following interactions occur: lexical frequency interacts significantly with prosodic domain $F(1, 120)=4.825$, $p=.03$ and with stress position $F(1, 67)=4.130$, $p=.046$. Prosodic domain also interacts with V2 backness $F(1, 120)=7.964$, $p=.006$. The only other significant interaction occurs with the independent variables of lexical frequency and V1 backness for /d/ $F(1, 122)=5.253$, $p=.024$ and for /p/ $F(1, 181)=5.097$, $p=.025$. In none of these cases is *Eta* (a measure of effect size) greater than .062, indicating a very small strength of the relationship between pairs of interacting variables and L scores. Due to the extremely small numbers of significant interactions, low effect sizes and the lack of a clear pattern, further discussions will not incorporate these observations.

5.1.6 H6: Lenition of geminates

The hypothesis H6 states that geminate segments will lenite to long fricatives. Stated a different way, it is predicted that if geminates lenite they will not reduce in duration such that their length approximates that of singleton segments. If geminate resistance to lenition (Kirchner 1998, 2000) is real, however, we should see relationships between lenition indicators and duration as follows:

1. Reduced VOT duration, increased voicing, and increased intensity should each entail reduced constriction duration

2. Visible signs of lenition in their spectrograms should entail constriction durations approaching those of singleton segments.

The acoustic data in this study serves as counterevidence to these predictions.

As a starting point in the testing of H6, the data in Table 5-14 and Table 5-15 present the mean values of constriction durations and other lenition indicators for both geminate and singleton segments. There are differences in relative constriction duration based on underlying length:

Table 5-14.
Lenition indicator means for oral geminates

	N	Relative constriction duration	Relative VOT duration	Relative intensity (dB)	Relative voicing (RPP)
Voiceless	244	.34	.10	-21.62	.75
Voiced	108	.33	.04	-10.15	.90

Table 5-15.
Lenition indicator means for oral singletons

	N	Relative constriction duration	Relative VOT duration	Relative intensity (dB)	Relative voicing (RPP)
Voiceless	609	.26	.05	-14.59	.70
Voiced	325	.20	.02	-7.66	.92

Prediction (1) above was tested by running correlations between relative constriction durations and each other lenition indicator variable on the voiceless and voiced geminate subgroups. In none of the cases tested does duration correlate with the other indicators in a direction that supports H6.

Significant negative correlations are found between relative constriction duration and relative VOT duration for both the voiceless group (rho=-.582, *p*=.000) and the voiced group (rho=-.196, *p*=.042). Figure 5-3 and Figure 5-4 illustrate this negative relationship where, as VOT duration decreases (indicating weakening), constriction duration does not decrease.

Figure 5-3.
Relative constriction x VOT durations (voiceless geminates)

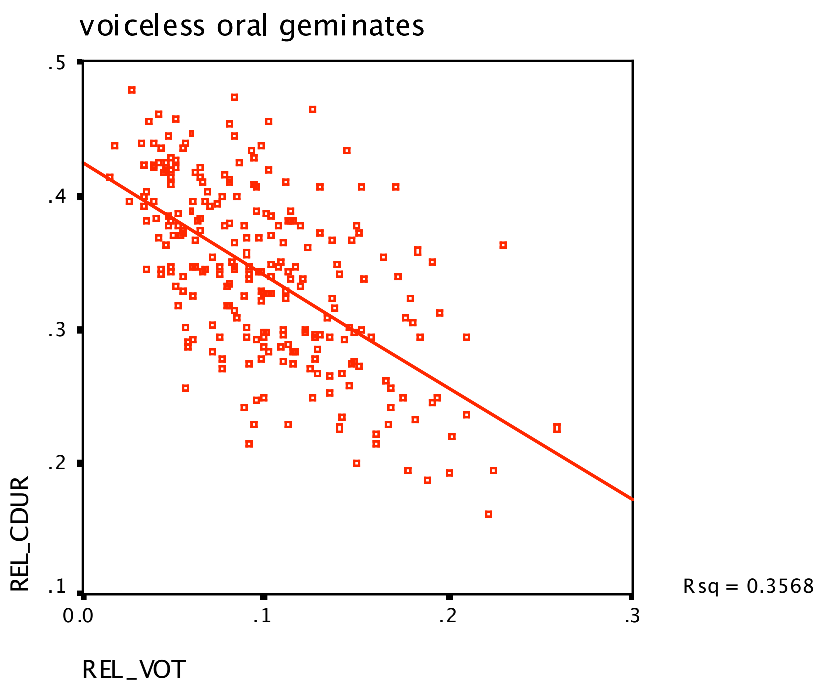
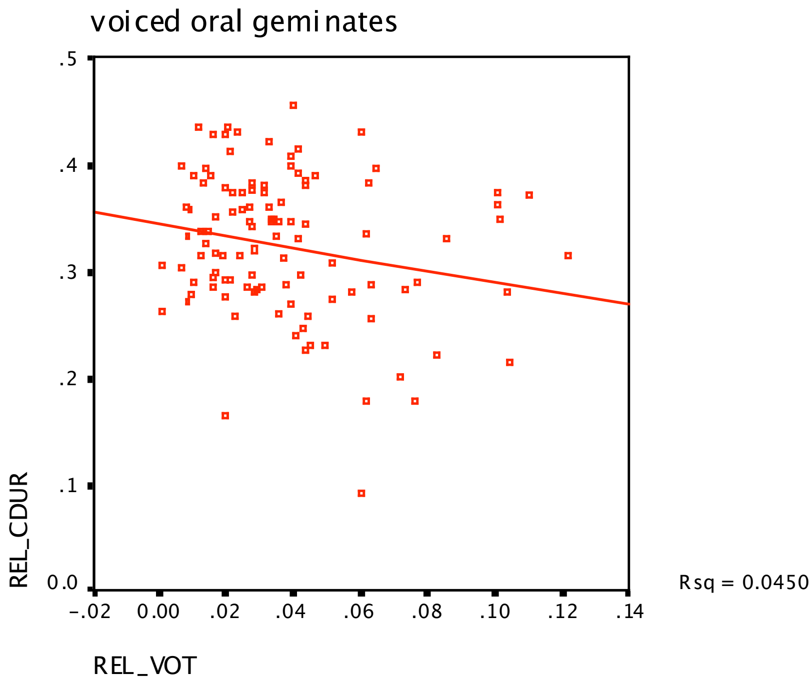


Figure 5-4.
Relative constriction x VOT durations (voiced geminates)



Prediction (1) also requires a significant relationship between voicing and constriction duration: if geminates reduce in length when leniting, we will see a negative correlation between voicing and duration. In fact, however, we see exactly the opposite relationship in the case of voiceless geminates (rho=.204, *p*=.001) and no significant relationship in the case of voiced geminates (rho=.137, *p*=.157). Again, these correlations are made clear by the scatterplots in Figure 5-5 and Figure 5-6.

Figure 5-5.
Relative constriction x voicing (voiceless geminates)

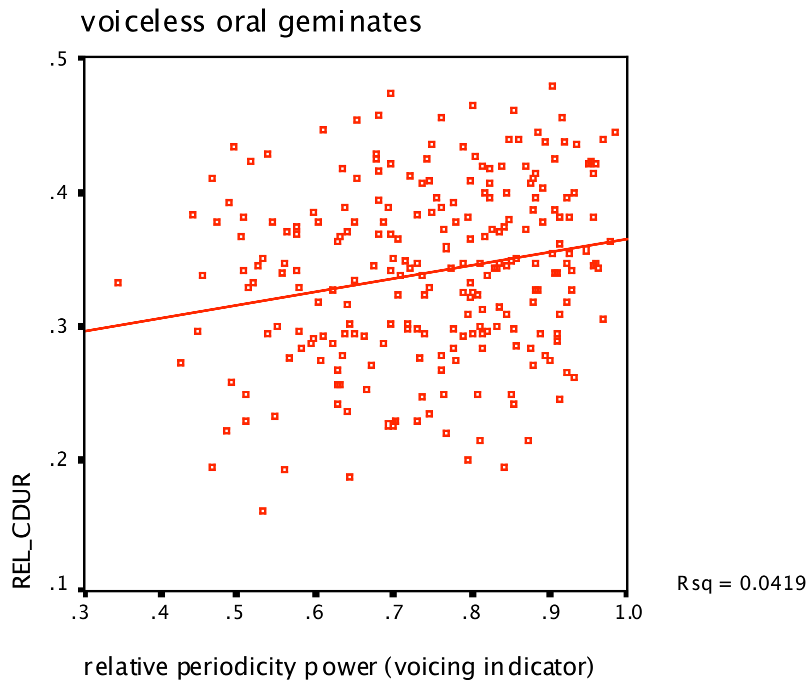
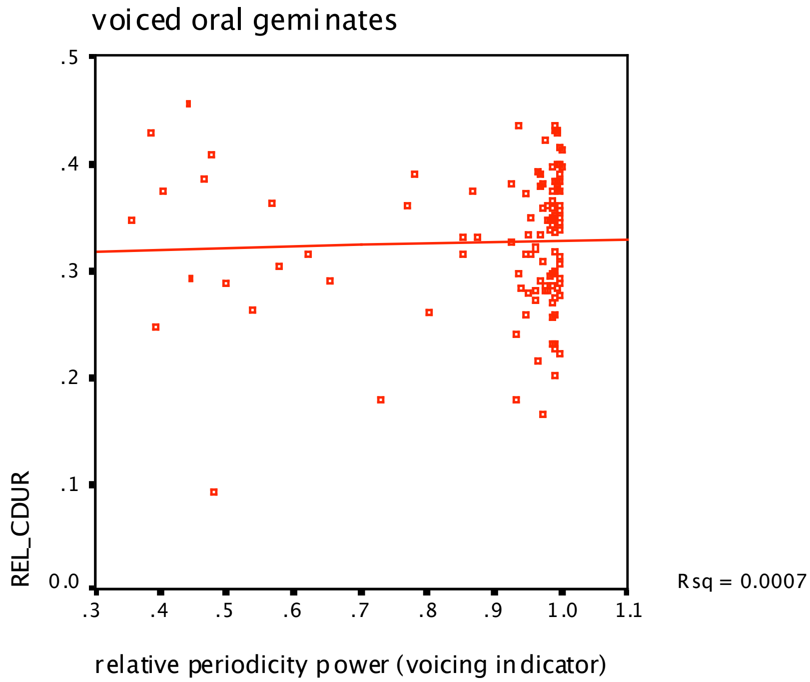


Figure 5-6.
Relative constriction x voicing (voiced geminates)



Finally, Prediction (1) would be partially satisfied if a significant negative correlation were found between relative constriction duration and intensity (geminates exhibiting lenition in the form of increased intensity should have reduced durations). There is a slight, but not significant, correlation in the set of voiceless geminates (rho=-.063, p=.326) and no significant trend in the set of voiced geminates (rho=.088, p=.365), as the plots in Figure 5-7 and

Figure 5-8 illustrate.

Figure 5-7.
Relative constriction x intensity (voiceless geminates)

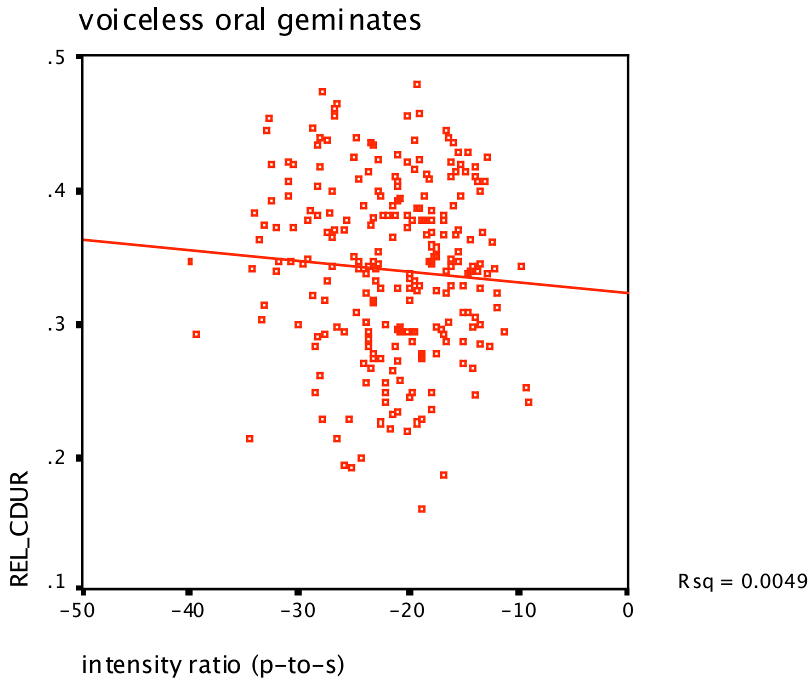
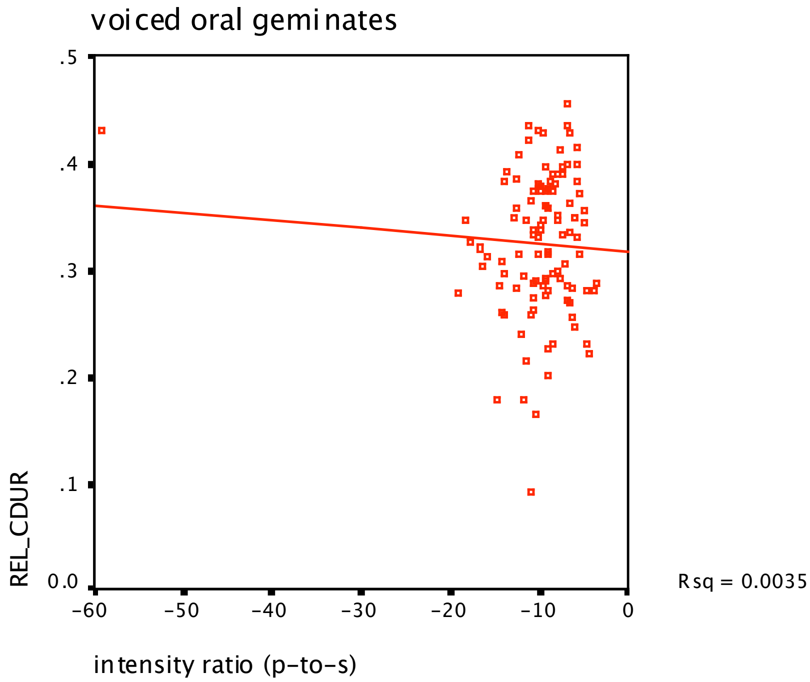


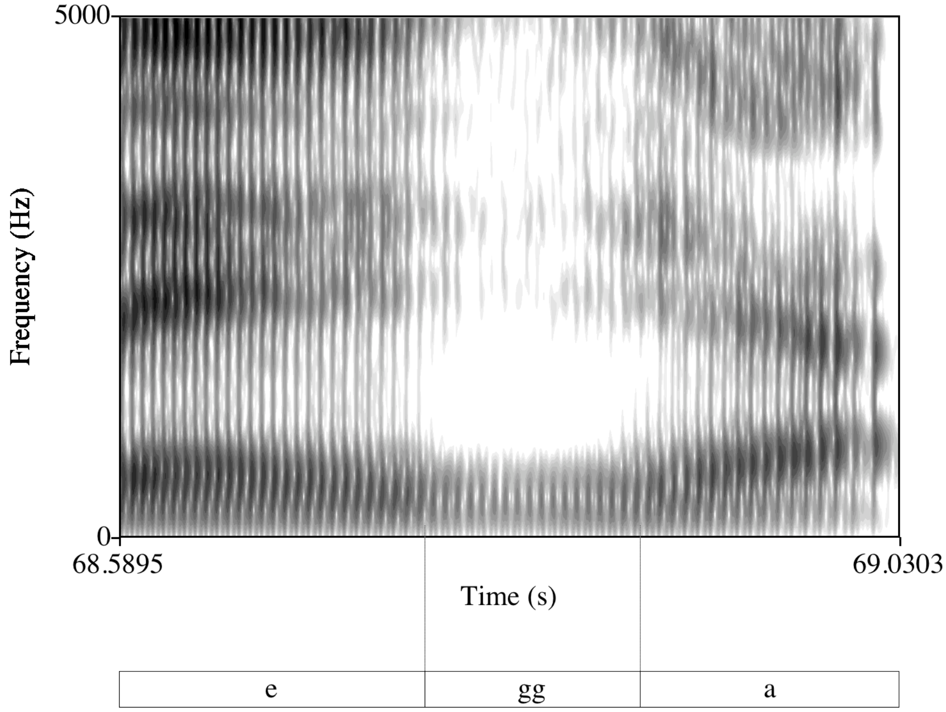
Figure 5-8.
Relative constriction x intensity (voiced geminates)



Finally, it is important to examine the very rare cases (only 2 in 353[49]) of geminate segments that exhibit visible signs of lenition in their spectrograms. Figure 5-9 is the spectrogram of /gg/ leniting to an approximant, but maintaining a relative oral constriction duration of .28. This duration is, in fact, below the mean of voiced geminates (.33, from Table 5-14, above), but well above the mean duration of voiced singletons (.20, from Table 5-15, above).

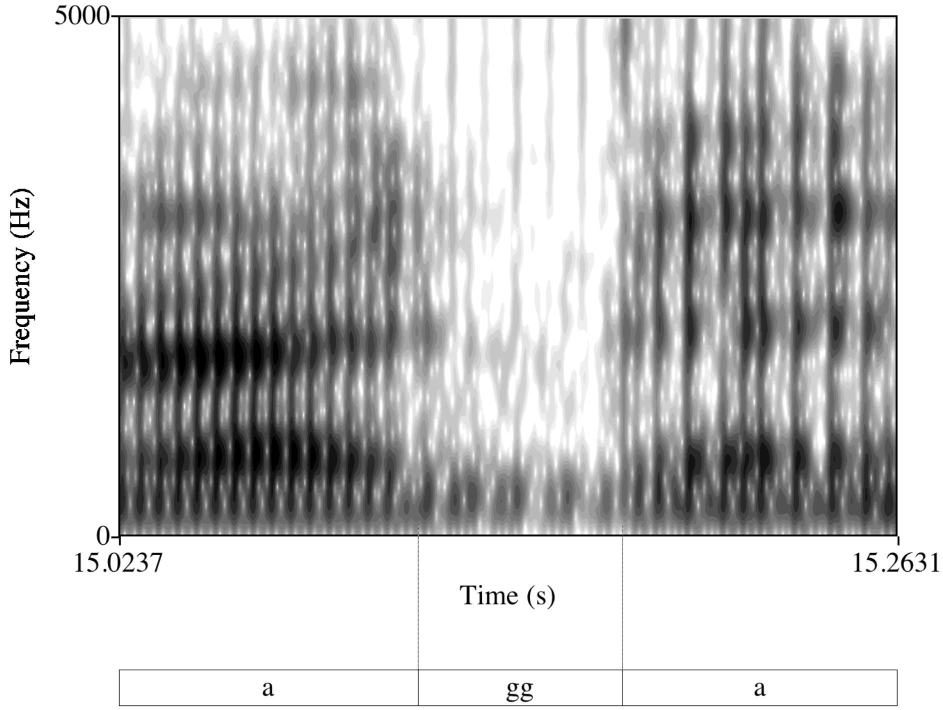
[49] The first of these cases occurs in a separate study which was recorded and analyzed outside of the main dataset. The subject is F1, one of the original subjects, and the acoustic measurement methods are those used for the tokens in the original data. This case is included because it is the only case of geminate approximantization.

Figure 5-9.
Spectrogram of /egga/ sequence



The voiced velar geminate /gg/ is again shown in Figure 5-10, this time with a greater amount of noise indicating more frication than approximantization. Its duration is .26, again, below the mean for voiced geminates, but higher than the mean for voiced singletons.

Figure 5-10.
Spectrogram of /agga/ sequence



Although the instances of geminate stops exhibiting radical lenition are severely limited, there are quite a few with more subtle signs of lenition in their spectrograms. We can therefore look at the constriction durations of geminates surfacing as fricated stops (resembling canonical stops in all ways, except that their constriction period contains some diffused noise not generally associated with stop closures) and as semi-fricatives (containing two distinct periods, the first with very low amplitude or waveform activity and the second with diffused noise resembling VOT, but with no visible burst between the two). There are 33 of these cases in 352 of these visibly-lenited geminates, and the following observations on their constriction durations are noteworthy[50]:

1. 27% have relative constriction durations less than or equal to the mean for singleton segments.

2. 24% have relative constriction durations somewhere between the means for singleton and geminate segments.

3. **49%** have relative constriction durations **greater than or equal to** the mean for geminate segments.

In other words, half of all geminate segments exhibiting visible signs of lenition maintain geminate-like constriction durations. Referring back to the lenited geminates in Chapter 3 (found in Table 3-30), we also note that the velar geminates /kk/ and /gg/ account for 22 of the 33 cases.

The correlations, spectrograms, and constriction duration data presented in this section lead to the following observations:

1. Reduced VOT duration, increased voicing, and increased intensity do *not* entail reduced constriction duration

2. Visible signs of lenition in their spectrograms do *not* entail constriction durations approaching those of singleton segments.

The cases of geminate lenition are limited, the hypothesis that geminates will not lenite to fricatives without degeminating is neither confirmed nor rejected based on the small amount of evidence.

[50] Comparisons of duration means are both phoneme- and subject-specific.

5.1.7 Summary of hypothesis testing

Table 5-16 sums up the outcome of the statistical tests discussed in this chapter. On the basis of the statistics alone, no clear pattern emerges, and the hypotheses relating to frequency, prosodic environment, stress, and vowel backness cannot be confidently confirmed for the majority of phonemes under consideration.

Table 5-16.
Hypothesis test results

Hypothesis	/b/	/d/	/g/	/p/	/t/	/k/	geminates
H1 – velars will lenite more	--------CONFIRMED-------						n/a
H2 – segments in high-frequency items will lenite more						C	n/a
H3 – word-internal segments will lenite more				C	C		n/a
H4 -- segments with left-stress will lenite more	C				C		n/a
H5 – segments flanked by [+back] vowels will lenite more							n/a
H6 – geminates will lenite to long fricatives							C??

The following significant observations are observed:

Observation 1: Velars lenite significantly more than labials or dentals, although some speakers exhibit a dispreference for /k/ lenition.

Observation 2: Velars are the only segments whose lenition is positively affected by high lexical frequency.

Observation 3: Velars are the only segments which lenite more when V1 is [-back]

The following trends are not significant, but are consistent with the outcomes of statistical tests in that they support a difference in velar and non-velar behavior:

Observation 4: Velar lenition is generally the least affected by the prosodically strong environments of word and foot edges.

Observation 5: Velar geminates exhibit signs of visible lenition *other than length reduction* more often than non-velar geminates do.

In addition to illuminating the special status of velars, the qualitative and quantitative descriptions in this and previous chapters illustrate the gradience of lenition, the radical lenition of velar segments, the regular application of lenition throughout the entire class of stops in the Italian consonant inventory, and the presence of intersubject variation in preference towards velar lenition. Chapter 6 examines the lenition process in Florentine Italian in light of these observations.

6 Discussion and Conclusions

This final chapter presents a descriptive and explanatory analysis of the lenition patterns observed in Florentine Italian. Based on the patterns that emerge through quantitative analysis of stop weakening in this dialect, the diachronic observations, and the social circumstances of speakers in the Florentine linguistic community, the *Gorgia Toscana* can and should be viewed as a sound change process that involves a mixture of physiological, conceptual, and social motivations. This explanation of Florentine lenition draws on phonetically-based theories of coarticulation and perception, phonological theories of symmetry and contrast-preservation, and social theories of linguistic change and variation. The interaction of various intrinsic and extrinsic linguistic forces are used to address the outcome of Chapter 5's hypothesis testing. *Gorgia Toscana* has not heretofore been analyzed under this type of integrated approach.

Section 6.1 discusses *Gorgia Toscana* as both a gradient and variable process, based on the data in the current study. Section 6.2 presents a number of observations arising from the present research and previous findings, and formulates questions that should be addressed by any theoretical explanation of *Gorgia Toscana*. Sections 6.3 and 6.4 review the explanatory power of articulatory and perceptual factors with respect to these questions. Section 6.5 discusses the ability of abstract featural representations in accounting for some of the patterns in the data. Section 6.6 suggests the role that social factors may play in explaining both the adoption of lenition as a regular dialectal process and the synchronic constraints on the process. Section 6.7 examines *Gorgia Toscana* patterns in light of Hume and Johnson's (2001) model of interacting forces on a language's patterns of sound change. The final sections of this chapter address the limitations of and contributions made by the present study.

6.1 Gradience and variation in Gorgia Toscana

Although previous studies (Marotta 2001; Sorianello 2001) have shown that *Gorgia Toscana* results in numerous surface realizations of the underlying consonants involved in the process, the present study indicates a true gradience in the output. However useful it may be to discuss lenition in terms of categorical alternations derived from underlying segments, the acoustic data herein show that changes resulting from lenition lie *at all points* along a continuum of weakening. This observation has implications for the methods used in measuring sound change and also for the descriptive and explanatory power of frameworks incorporated in any account of the data. On the one hand, it appears that lenition can assume infinite forms through minor fluctuations in articulatory motions (corresponding with minor fluctuations in a number of acoustic dimensions).   On the other hand, our ability to capture and measure this gradience makes a formal analysis difficult. The dilemma is between focusing on the actual gradience and ignoring, or at least abstracting away from it, in order to explain a process as simply as possible and to formulate learnable, grounded constraints.

A limited number of patterns can be found in the current study's data, but for the most part, these data suggest that the process of lenition in Florentine is highly variable – both among and within speakers. Not only are inputs associated with a possibly infinite number of surface forms, but the choice of these forms is not consistent. The locus of lenition varies: some consonants appear to be affected by prosodic environments in a way that other consonants are not. We have also seen that the degree of lenition varies: /k/ appears prone to categorical extreme weakening, but only some of the time; all segments surface as complete stops at some times, as fricatives or approximants at others. And we have seen that, despite several decades of observations that /k/ is most prone to lenition, /k/-weakening appears to be suppressed by certain subjects, and possibly exaggerated by others.

Variation, like gradience, is a fact that must be taken into account in studies like the present one. As Anttila (2002: 206) points out, variation is conditioned not only by external factors like gender, style, age, register, social class and so on, but also by factors internal to the grammar of a language (phonology, morphology, syntax, lexicon). The theoretical discussion in the remainder of this chapter will consider specific instances of variation in *Gorgia Toscana*, such as the categoricity of /k/ lenition and the suppression/accentuation of /k/ lenition. It will also discuss ways in which phonological accounts can address differences in the locus of variation.

6.2 The facts of Gorgia Toscana

A modern quantitative analysis forms the core of the present study, but there have been previous observations regarding the *Gorgia Toscana* and other sound-changing processes. These previous observations relate to diachronic patterns, categorization as a certain type of weakening process, asymmetrical behavior of the affected segments, and social factors. Past and present findings are summarized here, as the core of facts that must be addressed by an analysis of *Gorgia Toscana*.

(1) Diachronic patterns

(a) At the onset (early 14^{th} century) of the sound change to be known as *Gorgia Toscana*, the velars /k/ and /g/ were the only segments observed to lenite (Izzo 1972 and references therein).

(b) Lenition of other stops was not observed until approximately 250 years later (Izzo 1972 and references therein).

(c) Currently, all stops undergo lenition in Florence, albeit to varying extents (Giannelli and Savoia 1978; Marotta 2001; Sorianello 2001; present study).

(d) Lenition of velars, despite its innovation six centuries ago, has not become completely phonologized or undergone lexical diffusion.

(2) Process type

(a) *Gorgia Toscana* can be categorized as a post-lexical process, as it is variable and (to a certain extent) optional, not structure-preserving, more likely to apply in fast or casual speech, and generally exceptionless (Zsiga 1995: 576).

(b) *Gorgia Toscana* manifests itself as a gradient process, with surface variants occurring along a continuum and not confined to categories (present study).

(c) Post-lexical processes have been characterized as phonological, feature-based changes, and also as phonetic, articulatorily driven changes (Zsiga 1995: 577).

(d) Phonological changes, being based on abstract features, are not necessarily articulator-based alternations. Phonetic changes viewed as the outcome of gestural overlap or decrease in gestural magnitude necessarily entail relationships among articulators (Browman and Goldstein 1992).

(e) The consonants undergoing intervocalic lenition in Florentine Italian differ with respect to the articulators involved.

(3) Asymmetrical behavior and disorder in the hierarchy

(a) Velars, aside from their historical status as the only leniting segments, have been observed to lenite more frequently and more radically than labials or dentals (Giannelli and Savoia 1978; Marotta 2001; Sorianello 2001).

(b) The Italian phoneme inventory includes labial and coronal fricatives, but does not include velar fricatives.

(c) Velar lenition appears bimodal, in that velar segments exhibit higher rates of extreme weakening/deletion than of approximantization (Marotta 2001; present study).

(d) Only velar lenition is tied to lexical frequency, the effects of which have been argued to motivate the subset of sound changes that is physiologically motivated (Phillips 1984; Bybee 2002).

(e) There is a distinct difference in velar lenition among the subjects in the present study – M1 and F1 are the only subjects who lenite /k/ more than any other segment.

(f) Variation in lenited segments by place of articulation is found among the different regions of Tuscany (Giannelli and Savoia 1978/79; Cravens 2000).

(4) Social factors

(a) It is widely accepted for Italian speakers to retain their local accents (Lepschy and Lepschy 1977: 37, 15).

(b) Florentine Italian has been considered the national standard since the early 14^{th} century due to the city's political, economic, and cultural prestige; central geographic location; and the publication of Dante's *The Divine Comedy* in the dialect (Lepschy and Lepschy 1977: 22).

(c) The province of Florence enjoys a prestigious reputation among residents and non-residents, as indicated by a number of non-linguistic factors including tourism rates, economic strength, quality of life perception, and cultural/historic/artistic importance. (UNESCO, ISTAT, EUROSTAT)

(d) Lenition of /k/ is a stereotypical marker of the Florentine dialect, and non-Florentine Italians perceive lenition of /k/ more than they perceive lenition of other stops (Cravens 2000: 14).

(e) Two speakers in the present study lenite /k/ more than any other consonant. These subjects have markedly different social features than the four subjects who lenite /k/ to a lesser extent.

The facts enumerated above, suggest five questions concerning lenition in Florentine Italian:

(1) Why might both voiced and voiceless velars exhibit special status diachronically, and, in many cases, synchronically, in this sound-changing process?

(2) How can gradience in the surface manifestations be accounted for?

(3) Why did non-velars eventually become (and why do they continue to be) susceptible to the process?

(4) Why does the voiceless velar /k/ show a tendency towards categorical extreme weakening?

(5) How can intersubject variation, particularly with reference to the preference or dispreference of velars, be explained?

The following sections discuss the interrelated explanatory power of independent motivators with respect to these questions: spatiotemporal arrangement of articulators account for the special susceptibility of velars to lenition and the gradience observed in surface manifestations; perceptual factors (both acoustic and cognitive) play an additional role in accounting for greater lenition of velars than non-velars; reference to abstract features can be used to account for the spread of lenition within a natural class of segments, the tendency for velars to undergo categorical weakening, and some of the observed variation in locus (either prosodic or register-based). Independently of phonetic and phonological factors, social constraints are adduced to explain both the historic adoption of *Gorgia Toscana* as a regular sound changing process in Florentine Italian and the pattern of intersubject variation in which we see preference and dispreference for /k/ lenition.

6.3 Production-related approaches to lenition and Gorgia Toscana

<u>6.3.1 Direct evidence for an articulator-based approach</u>

A phonetic account of *Gorgia Toscana* that directly references articulator movements in space and time has two advantages. First, it can explain the asymmetrical lenition behavior of consonants within a natural class by appealing to articulators without reference to abstract features. Second, by viewing lenition in terms of temporal and spatial movements, all shades of variation may be captured – from non-application of the lenition process to maximal application (deletion) and everything in between. It does not, however, account for the categorical extreme weakening of velars, or intersubject variation in the frequency of velar lenition.

We might view *Gorgia* as a physiological coarticulation of consonants and vowels rather than a process that categorically alters the continuancy feature of a consonant. This purely articulatory theory claims that articulator motions will differ along dimensions of space and time, depending on neighboring motions (Browman and Goldstein 1990, 1992).

One plausible explanation of a phonetic motivation to lenite velars more than non-velars comes from Browman and Goldstein's model of Articulatory Phonology, which "attempts to describe lexical units in terms of [**gestures**] and their interrelations" (Browman and Goldstein, 1992: 156). They define gestures in this model as "discrete, physically real **events** that unfold during the speech production process" (ibid) and are "specified using a set of related **tract variables**" (ibid). A tract variable "characterizes a dimension of vocal tract constriction" (ibid) – both in terms of the location of the constriction and the degree of constriction – and involves a set of articulators acting together. Figure 6-1 demonstrates the relationship among gestures, tract variables, and articulators by describing the production of /k/ using the concepts introduced above.

Figure 6-1.
Relationship between gestures, tract variables, and articulators

The **gestures**	*closed velar tongue body*	are specified by the **tract variables**	*tongue body constriction location*	which involve the **articulators**	*tongue body*
			tongue body constriction degree		and
	wide glottis		*glottis constriction degree*		*glottis*

Table 6-1 lists the gestures involved in articulation of the six oral stops relevant to this study. Tract variable sets (lips, tongue tip, tongue body, velum, and glottis) are along the top of the table. The shaded boxes denote the gestures – specifications of constriction degree and location (if applicable) for the tract variables in each set.

Table 6-1.
Consonant gestures

	Lips	Tongue Tip	Tongue Body	Velum	Glottis
P	closed				Wide
B	closed				
t		closed dental			Wide
d		closed dental			
k			closed velar		Wide
g			closed velar		

In this model, sounds are contrasted in terms of gestures instead of abstract features, and thus, indirectly, in terms of the active articulators involved in each sound's production. The same information is presented for a set of five vowels in Table 6-2, where we see that the same tract variable set (Tongue Body) is consistently involved, with differing constriction degree and location.

Table 6-2.
Vowel gestures

	Lips	Tongue Tip	Tongue Body	Velum	Glottis
i			narrow palatal		
e			narrow palatal		
u	rounded		narrow velar		
o	rounded		narrow velar		
a			narrow pharyngeal		

Since fluent speech does not involve consonants and vowels produced in isolation, the organization of gestures must be arranged over time (Browman and Goldstein, 1992: 157). The schematic gestural scores in Figure 6-2 through Figure 6-7 show the VCV sequences /apa/, /aba/, /ata/, /ada/, /aka/, and /aga/. Note that velar closure gestures are consistently absent, as all articulations are oral.

Figure 6-2.
Gestural score of /apa/

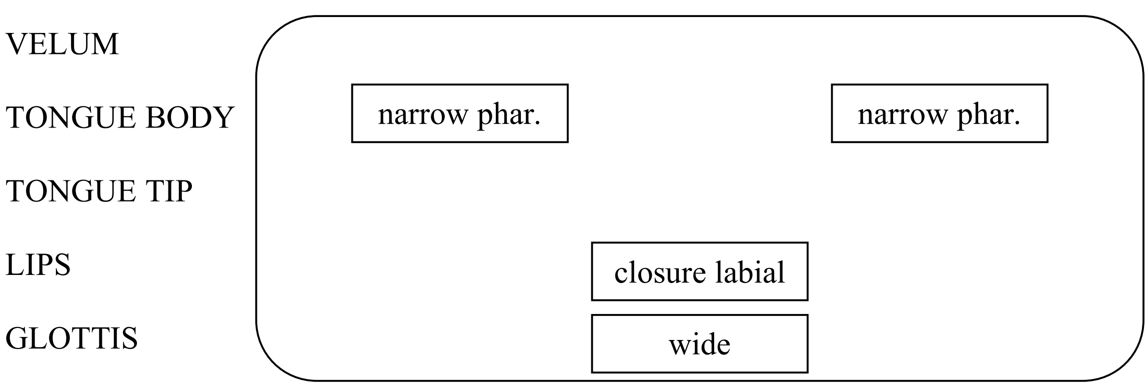


Figure 6-3.
Gestural score of /aba/

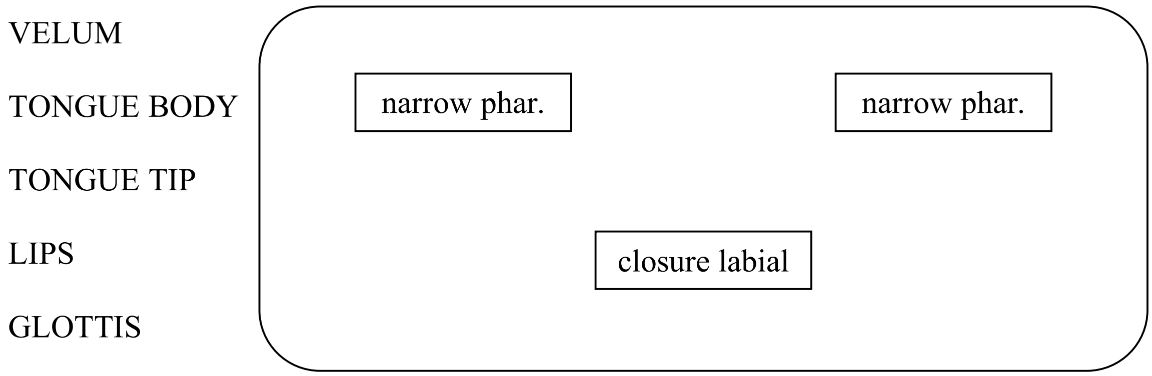


Figure 6-4.
Gestural score of /ata/

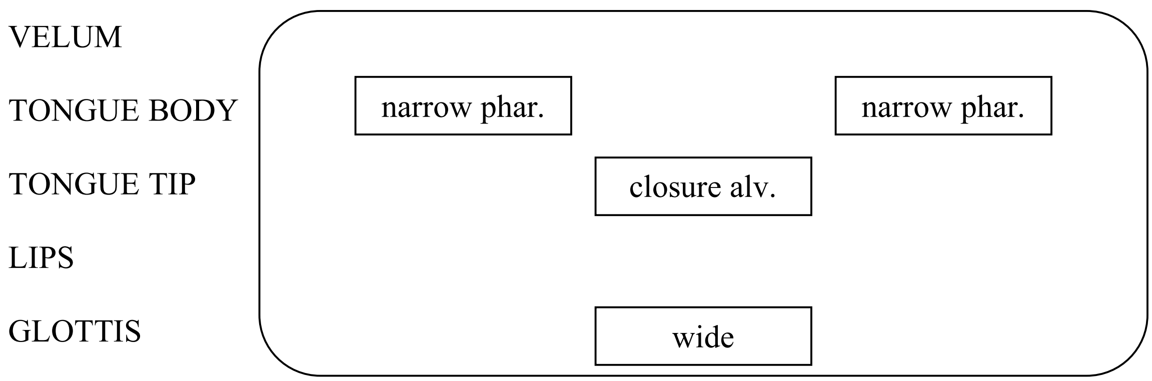


Figure 6-5.
Gestural score of /ada/

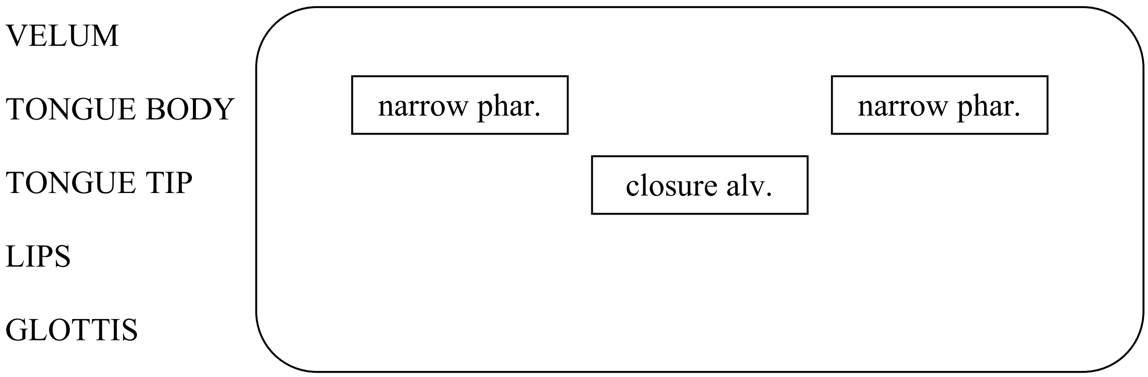


Figure 6-6.
Gestural score of /aka/

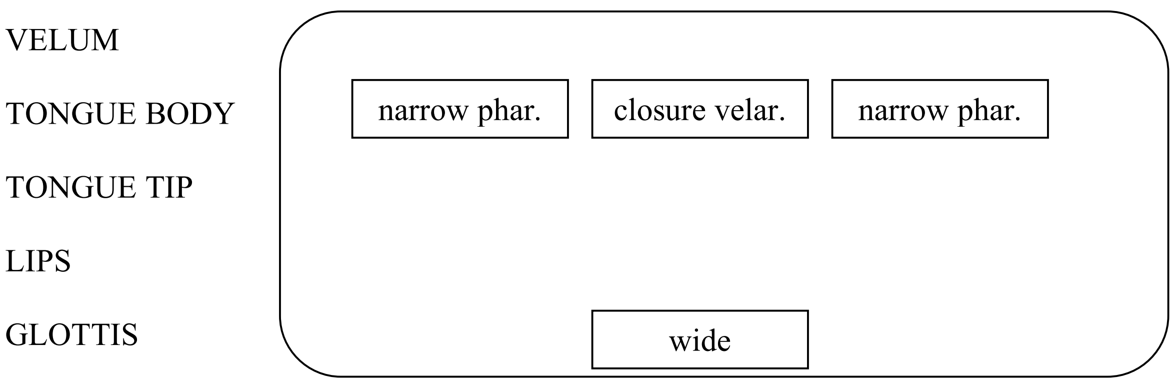
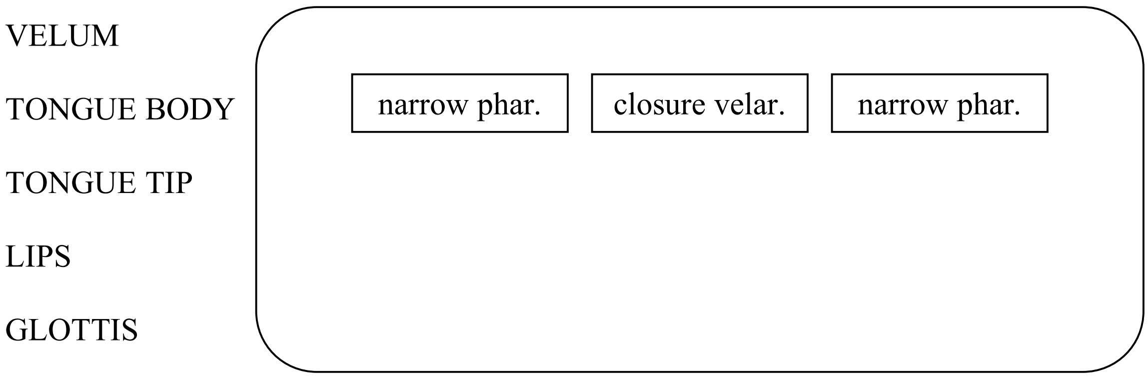
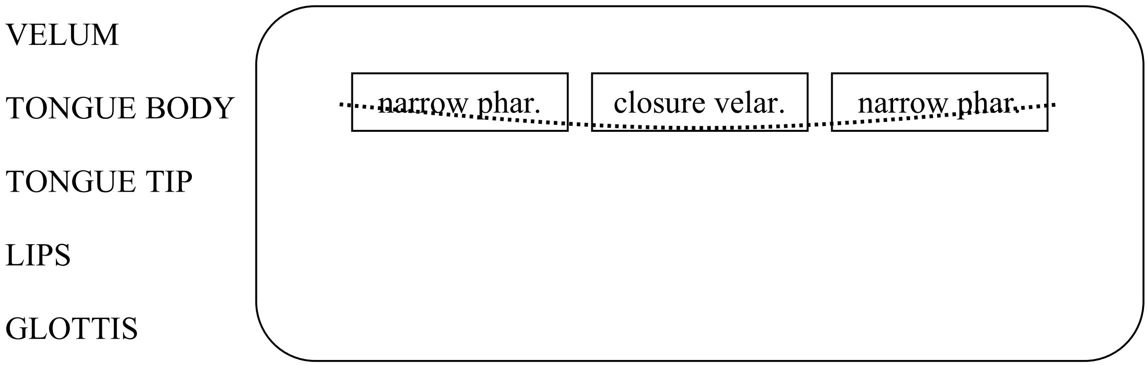


Figure 6-7.
Gestural score of /aga/



The gestural scores of /aka/ and /aga/ in Figure 6-6 and Figure 6-7, show that the same tract variable is specified by the gestures involved in producing each segment of the VCV sequence where C is a velar. This is not the case for VCV sequences involving labials and dentals: the consonants in those sequences involve a different tract variable than do the vowels. If we superimpose the articulatory trajectory associated with the gestures "narrow pharyngeal" for /a/ and "closure velar" for /k/ or /g/ onto one of the gestural scores in Figure 6-6 or Figure 6-7, we see that the tongue body, a very slow articulator due to its mass, has to achieve three sequential constriction/location targets if the /aga/ sequence is to result in a surface pronunciation of [aga].

Figure 6-8.
Gestural score of /aga/ with articulatory trajectory superimposed



In fact, Browman and Goldstein (1992: 165) argue that this target achievement is not possible:

> In the case where consonants and vowels share the same (TB) tract variables (e.g., the consonant [g] as in [aga] or [igi]), the consonant and vowel gestures cannot both simultaneously achieve their targets, since they are attempting to move exactly the same structures to different positions.

The result, then, is that the consonant gesture will vary in its constriction location, achieving a target somewhere between its original target and that of the surrounding vowels. Browman and Goldstein note specifically that only the *location* of constriction will be affected, not the degree of constriction (1992: 165), which on the surface poses a problem for a gestural analysis of lenition, because it is the latter that appears to be at play in the weakening of stops (this study; Lavoie 2001). This contradiction is easily resolved, though. Browman and Goldstein also claim that "in faster, casual speech, we expect gestures to show decreased magnitudes (in both space and time) and to show increasing temporal overlap [...] weakenings are consequences of these two kinds of variation in the gestural score" (1990: 17). Furthermore, they note Brown's (1977) observation that "a typical example of magnitude reduction might be the pronunciation of the medial (velar) consonant in 'cookie' as a fricative rather than as a stop" (1992: 173).

Given Browman and Goldstein's recognition that magnitude of constriction, not just its location, it is reasonable to conjecture that, while the articulation of velar consonants in VCV sequences may include a location shift, it is also likely to include a reduction in magnitude. Such a reduction would manifest itself as the difference between Figure 6-9 (where velar closure is achieved) and Figure 6-10 (where velar closure is attempted, but not achieved).

Figure 6-9.
Simplified gestural score of /aga/ with closure achievement

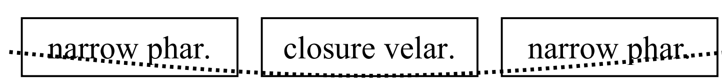


Figure 6-10.
Simplified gestural score of /aga/ with closure non-achievement

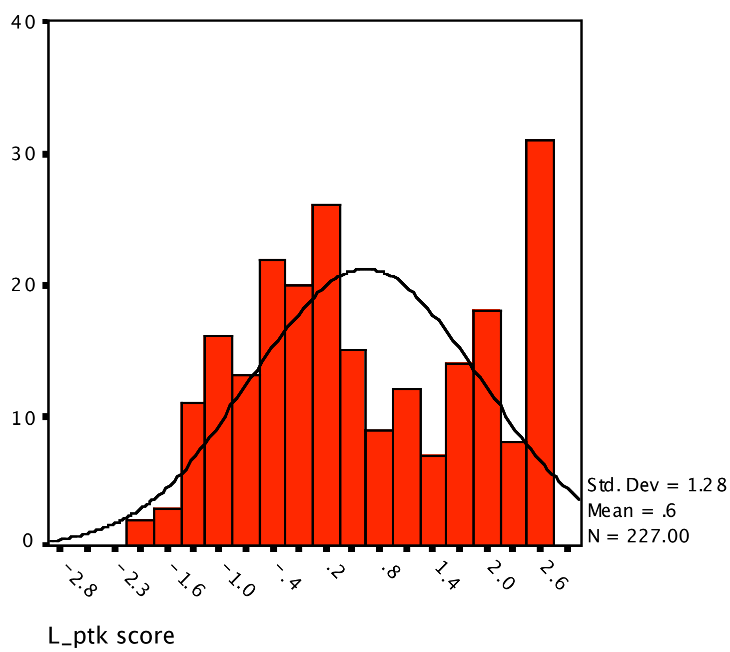
But why is it the consonant target that is altered, rather than the surrounding vowels' targets? Again, Browman and Goldstein answer the question by positing a fundamental difference between consonants and vowels, where "vowels act as a kind of background to the "figure" of the consonants" (Browman and Goldstein 1990: 11). Gafos (1996: 31) also discusses the vowels within a VCV sequence as "articulatorily contiguous" – the slowness of vocalic gestures allows them to persist during the articulation of the consonant. If vowels in connected speech are more articulatorily fundamental or contiguous than the interspersed consonants, this characteristic might impede their alteration. Taken together with the inability of similar gestures to simultaneously reach their degree targets, velar consonants will be forced to weaken in the Articulatory Phonology model.

An additional advantage of Articulatory Phonology with respect to the lenition process of *Gorgia Toscana* is that it can capture gradience in the output. Since duration and magnitude are measured on continuous scales, any and all values for these two variables are logically derived outcomes of lenition. As the previous chapters attest, the surface manifestations of weakening in Florentine Italian are generally non-categorical: L assumes analog-like values.

The disadvantage of a purely articulator-based phonetic explanation to the synchronic observations of *Gorgia Toscana* is its difficulty in accounting for non-velar lenition, categorical behavior of velars, and variable degree of velar lenition among subjects. The model does not provide a strong motivation for the physiologically-motivated weakening of other consonants, as natural classes play no role in Articulatory Phonology: weakening is a result of identical gestures being required in a time period too short to allow them to reach their goals, and the gestures involved in labial and dental articulations are not identical to those involved in vowel articulations. Nonetheless, the data in the present study confirms the lenition of non-velars.

Browman and Goldstein's model also encounters difficulty in accounting for what appears to be the categorical extreme weakening of the voiceless velar stop. The histogram below, repeated from Chapter 4, indicates a bimodal distribution of L scores for /k/, as evidenced by the jump in frequency of weak approximant s at the extreme right of the diagram.

Figure 6-11.
Histogram of L scores for phoneme /k/
(present study)



Articulatory Phonology does not predict a distribution where two forms of reduction (fricativization and weak approximantization or deletion, for example) occur more frequently than a form of reduction lying at an intermediate stage between them (such as approximantization). Being a theory of gradual reduction in duration and magnitude, Browman and Goldstein's model predicts that intermediate stages of reduction will consistently lie between two extremes with respect to frequency of occurrence, so that the distributions in Figure 6-12 and Figure 6-13 are expected, but the distribution in Figure 6-14 (which is attested in the present study) is not:

Figure 6-12.
Hypothetical normal distribution

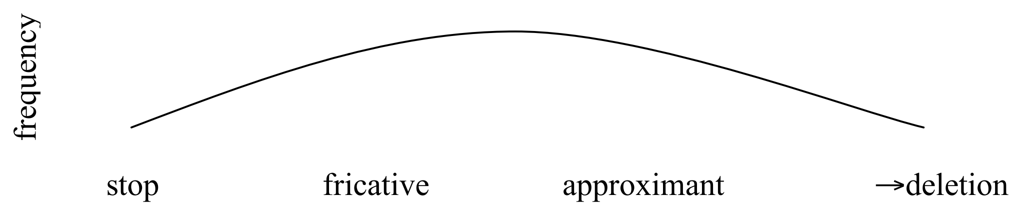


Figure 6-13.
Hypothetical linear distribution

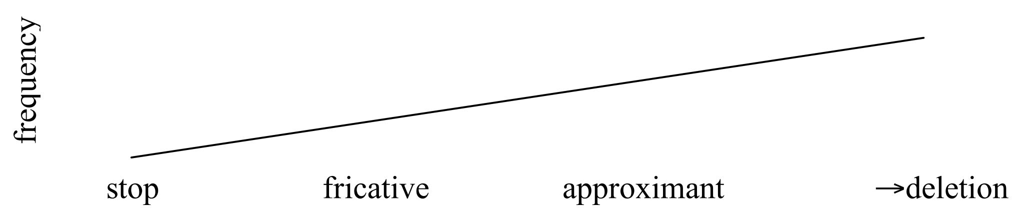
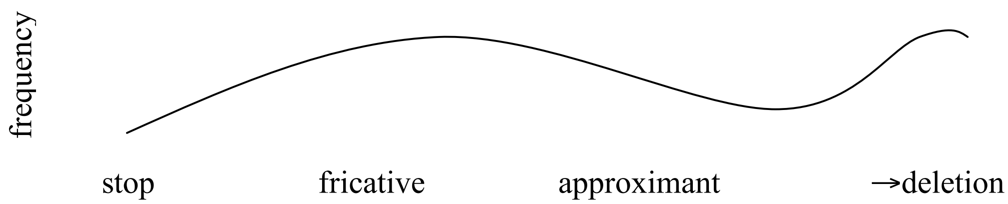


Figure 6-14.
Hypothetical bimodal distribution



A purely articulatory model is also challenged by the observation that some subjects exhibit a dispreference to lenite /k/ -- historically and synchronically the favored segment in the process of *Gorgia Toscana*. Referring only to physiological factors, Articulatory Phonology predicts that velars should always lenite, allowing no room for the suppression of these segments' weakening or for the higher frequency of lenited non-velars in any individual subject's speech.

Kirchner (1998) notes an additional limit of the articulatory approach: being a theory of gestural reduction and not gestural change, Articulatory Phonology in its strongest form has little to say about the replacement of a tongue body gesture by a glottal gesture in debuccalization (unless the glottal gesture exists and the tongue body gesture is simply reduced completely). Given the previous accounts of /k/ leniting to [h] (Giannelli and Savoia 1978), a gesture-based model fails to account for the data[51].

[51] There is another possibility. As no articulatory studies of *Gorgia Toscana* exist, it is at this point impossible to say whether debuccalization actually occurs. The fact that previous studies have used [h] to represent an allophone of /k/ does not necessarily mean that /k/ debuccalizes.

Thus, while a purely articulatory approach can account for the earlier and more frequent lenition of velars as well as for gradient lenition patterns, it is not capable of explaining all of the patterns observed in this study.

In addition to the similarity of articulatory gestures as a motivation for early and more frequent velar lenition, there is other direct evidence supporting a phonetic aspect of *Gorgia Toscana* that targets velars preferentially. This is partially grounded in the principle of physics known as Boyle-Mariotte's Law, which states that "for a given mass, at a constant temperature, the pressure times the volume is constant." In equation form, this will look like

$$PV = constant$$

and entails that any reduction in volume will result in an increase in pressure, or vice-versa, so Boyle's Law also holds that "for a given mass, at a constant temperature, pressure varies inversely with volume." From this observation, we can note that articulations involving closure at a location farther back in the oral cavity necessarily reduce the available volume for air exiting the lungs and therefore increase intraoral pressure, and this is in fact well-documented in treatments of place-of-articulation effects on voicing such as the Aerodynamic Voicing Constraint, or AVC, (Ohala 1997: 92). Stevens (1997: 492) asserts "the force from this [increased intraoral] pressure causes the walls of the vocal tract and of the glottis to displace outwards." But why should higher air pressure have an effect only on lateral displacement of the oral and glottal walls? In other words, any pressure sufficiently high to result in a structural change of the vocal tract might also be high enough to result in leakage through the stop closure, particularly when, as in the case of velars, the pressure is multiplied by a reduced amount of surface area behind the closure that is able to accommodate the higher pressure (Ohala 1997: 93).

In light of the Articulatory Phonology model and aerodynamic principles involved in consonant production, complete closure of velar stops is dually impeded in a way that labial and dental stop closure is not. First, the tongue body gestures necessary for velar stops face an obvious hurdle in reaching their closure targets due to their increased mass and their shared tract variable set with that of the surrounding vowels. Second, velars allow the greatest build-up of air pressure and the most reduced outlet for accommodating this pressure among the three places of articulation under discussion. Other things being equal, these aerodynamic principles suggest that velars may be more prone to leakage than other stops. Either of these arguments might substantiate a physiologically motivated aspect of *Gorgia Toscana* that targets velars; the argument is bolstered when they are considered together. The higher intraoral pressure built up behind a velar closure[52] will combine with the reduction in tongue body constriction predicted by the Articulatory Phonology model, resulting in an even greater tendency towards leakage and, hence, lenition.

Consider whether one could explain all lenition in *Gorgia Toscana* in a production-related framework other than Articulatory Phonology. While there are other

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[52] or attempted closure -- Since high intraoral pressure that is suddenly dropped is a necessary component of frication [Ohala 1997: 93], intraoral pressure can in fact build behind a constriction that is not completely closed.

theories, they do not account for the data in this study as elegantly. If we posit phonetic constraints that eschew reference to specific articulators, they become too general (and somewhat less phonetic). Overall reduction in effort (Kirchner 1998), reduction of constriction (Trask 1996), or increase in sonority would predict similar, consistent behavior of all consonants in all contexts, not simply those where articulators are identical. We would then see unmanifested *Gorgia* effects such as all consonants leniting to the same extent, or consonants leniting in non-VCV contexts. This is not what we observe, either diachronically or synchronically. Articulatory Phonology requires the phonology to generalize its effects, but this is a much better position to be in than positing a general constraint on production and subsequently requiring the phonology to make that constraint more specific by referring to articulators.

We might also ask whether a phonetic constraint that refers to specific articulators not in terms of their impact on constriction degree and duration, but only in terms of their influence on the degree of voicing (Ohala 1997) might be applicable to *Gorgia Toscana*. This type of constraint would certainly account for a different behavior of consonants in lenition processes (since increased voicing is a correlate of lenition in the present study). Again, however, we would see unmanifested patterns if only voicing constraints were considered: /p/ would be most likely to lenite among the set of voiceless stops, and /g/ would be the least likely to lenite among the voiced stops. Phonetic constraints on voicing fail to explain, on their own, the behavior of consonants where lenition is not only a manifestation of increased voicing, but a manifestation of decreased constriction and duration. Hence, they would require a substantial amount of stipulative repair in order to account for the patterns observed in this study.

There may be no single physiological explanation that can explain all of the data in this study, but direct reference to articulator movements in space and time appears to explain both the historic innovation and the ongoing favoring of velars that we see in *Gorgia Toscana* in the simplest way.

6.3.2 Indirect evidence for a physiological motivation

There is also indirect evidence supporting the physiological motivation of velar lenition. First, there is historical documentation of velar lenition occurring prior to lenition of labials and dentals. Second, this study shows that velars are the only segments whose lenition correlates positively with high lexical frequency.

Janda and Joseph (2003) provide cross-linguistic empirical evidence supporting Ohala's concept of phonetic conditioning as a necessary factor in the innovation phase of sound change. They argue that "sound change originates in a very 'small,' highly localized context over a relatively short temporal span" and that "purely phonetic conditions govern an innovation at this necessarily somewhat brief and limited point of origin" (Janda and Joseph 2003: 206). Subsequent changes, such as the spreading of the original phonetically motivated innovation, may arise from non-phonetic generalizations (phonological, morphological, lexical, or social), but phonetic factors are solely responsible for the innovation (Janda and Joseph 2003).

The detailed historical work of Izzo (1972) provides credible evidence that velar consonants were, for a period of approximately 250 years, the only consonants observed to undergo lenition in the Tuscan dialects. Assuming that velar lenition occurred at some point during the early history of Italian[53] then velar lenition, as an innovation, would necessarily be phonetically motivated according to Janda and Joseph's model. To the extent such a model is viable under further investigation of empirical sound-change data, and to the extent that historical records accurately represent early lenition of velars (and only velars), the innovation of velar lenition in, or prior to, the 14th century provides indirect evidence of velar lenition as phonetically motivated.

The other source of indirect evidence for phonetically conditioned lenition of velar segments is the effect of lexical frequency. Usage-based models (Phillips 1984; Bybee 2000; Pierrehumbert 2001) do not view the lexicon as a static list complemented by a set of language-specific phonological and feature-altering rules that derive surface representations from constant, underlying forms. Where a structural or generative model would list a single form-meaning pair in the mental lexicon, with differing outputs following from rules or constraints, the usage-based model allows ongoing revisions to the stored form. The task in this functionalist model is not to alter a constant form with the same rule, but to allow ongoing modification of the stored form (although structuralist models must also allow for such lexical modification in order to

[53] as opposed to having been carried over from Latin, which seems untenable given Latin's lack of velar fricatives (Allen, 1978: 34-35)

account for diachronic variation). Here frequency of usage plays a role: more frequent forms will be more easily accessed and therefore more frequently revised.

Bybee's model accounts for all variation in sound patterns in terms of gestural reduction. Variation is explained by appealing to frequency effects and flux in the relative strength of forms in a lexical network, such that items of higher frequency will be accessed more easily and more often. These items will have more opportunities for articulatory alternations, resulting in acoustically altered forms. New forms will be registered in lexical storage, sometimes resulting in a many-to-one form-meaning relation. Finally, the prototypical representative in a form-meaning network will be recentered, and the cycle continues.

Proponents of a usage-based model make different predictions about the role of word frequency in sound change. Phillips (1984: 336) puts forth the Frequency Actuation Hypothesis: "Physiologically motivated sound changes affect the most frequent words first; other sound changes affect the least frequent words first." Bybee (2000: 251) states that "many, if not all, sound changes progress in lexical items as they are used, with more frequently-used words undergoing change at a faster rate than less-frequently-used words." Pierrehumbert (2001: 1) argues "that mental representations of phonological targets and patterns are gradually built up through experience with speech."

Chapter 5 pointed out that the relationship between high lexical frequency and increased lenition is significant for only one segment out of the six investigated in this study – the voiceless velar /k/. Although the voiced velar /g/'s lenition is not significantly affected by lexical frequency, it does approach a significant level of interaction to a much greater degree than for any of the non-velar segments. Despite the lack of a significant relationship for /g/, however, lenition of the velar consonants is *more likely* to be conditioned by frequency than is lenition of other consonants. Taking into consideration Phillips' Frequency Actuation Hypothesis and Bybee's corroboration of it, the greater effects of frequency on the weakening of velars in the present study means their weakening is likely to be physiologically-motivated: in other words, *phonetic* in nature.

From the direct and indirect evidence discussed in this section, a physiological motivation, and in particular an articulator-based one, accounts for three aspects of *Gorgia Toscana*: the early lenition of velars at the state of innovation; the general susceptibility of velars to the weakening process observed in this study; and the gradient nature of lenition.

6.4 Perceptual approaches to lenition and Gorgia Toscana

In addition to being favored by production constraints, velar lenition is likely to also be favored by constraints on maintenance of perceptual contrast. The Italian phoneme chart in Table 6-3 is repeated here to illustrate the existing gaps in the inventory.

Table 6-3.
Italian consonant inventory
(Bertinetto and Loporcaro 2005: 132)

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Palatal	Velar	Labio-Velar
Plosive	p b		t d t͡s d͡z				k g	
Nasal	m			ŋ		ɲ		
Trill				ɾ				
Affricate					t͡ʃ d͡ʒ			
Fricative		f v	s z		ʃ (ʒ)			
Approximant						j		w
Lateral Approximant				ɮ		ʎ		

Following IPA standards, where symbols occur in pairs the symbol to the right represents a voiced consonant

The existence of labiodental fricatives /f/ and /v/ can clearly be seen as a perceptual obstacle for lenition of both bilabial and dental stops. Maddieson notes that the acoustic difference between bilabial and labio-dental fricatives is subtle, even to trained phoneticians, and the number of languages having a contrast between /f/ and /ɸ/ is likely to be around 3% (2005: 199) and also rather small for /b/ and /β/. With respect to acoustic differences between labiodental and dental fricatives /f, v/ and /θ, ð/, Jongman et al (2003: 1) note that "most research on fricatives has not been able to identify consistent acoustic characteristics that may serve to distinguish [them]." They cite previous studies that find /f/ and /θ/ and /v/ and /ð/ are most easily confused among fricatives (Balise & Diehl 1994) and that their distinction may be based on nonacoustic (for example, visual) information (Miller and Nicely 1955).

There are no existing velar fricatives in the Italian phoneme inventory, however – nor are there uvular, pharyngeal, or glottal fricatives. While minimization of perceptual confusion (Boersma 1998) and avoidance of weakly perceptible contrasts (Hume and Johnson 2001) can be seen as constraints against labial and dental lenition, no such constraint is applicable to velars in Italian. Velars are free to depart from a complete stop articulation without wreaking perceptual havoc, and their weakening is also more likely to phonologize without resulting in a phonological system that includes 'contrastive' entities that are in actuality difficult to contrast.

We might also ask whether perceptual information regarding a three-way (labial-dental-velar) place of articulation contrast is substantially degraded by lenition of any of the consonants in question. The answer is very likely no. Although Harris and Urua point out that "consonantal lenition degrades information in the speech signal" (2001: 73) and spirantization, in particular "suppresses the sustained interval of radically reduced amplitude associated with stop closure," (2001: 74), it does not appear to be the case that place of articulation cues are lost as a result of lenition. Stevens and Blumstein (1978) found that stop consonants were identified more consistently on the basis of their transitions only (and although bursts added information, they alone did not contribute to correct place identification. Analysis of the spectra of lenited /p/, /t/, and /k/ (to /ɸ/, /θ/, and /x/, respectively) in /aCa/ environments uttered by a male speaker

(M1) in this study indicate strong dissimilarities among the consonants, as Figure 6-15 through Figure 6-17 illustrate. Note the characteristics of each consonant in terms of peak amplitude (highest for /ɸ/, lowest for /x/) and spectral roll-off versus evenly distributed amplitude (greatest roll-off for /ɸ/, most even distribution for /θ/). Assuming the availability of such acoustic cues throughout the duration of the fricatives, it is unlikely that fricativization would result in degraded place of articulation contrasts among the three consonants in question.

Figure 6-15.
Spectrum of [ɸ] in 'rapa'
(Subject M1, repetition 1)

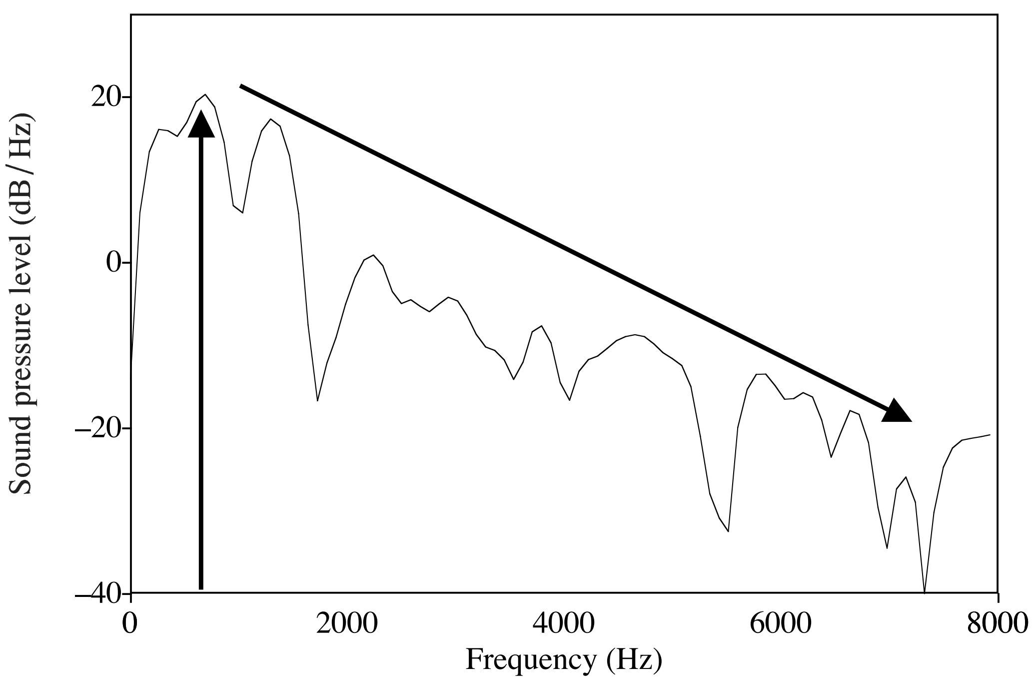


Figure 6-16.
Spectrum of [θ] in ‘rata’
(Subject M1, repetition 1)

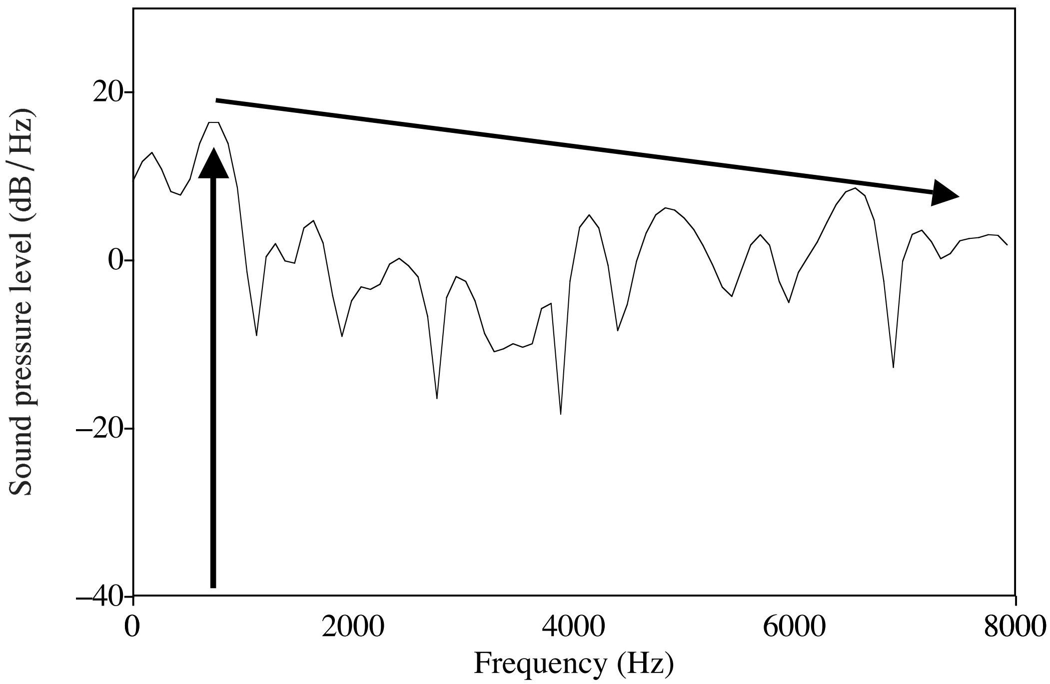
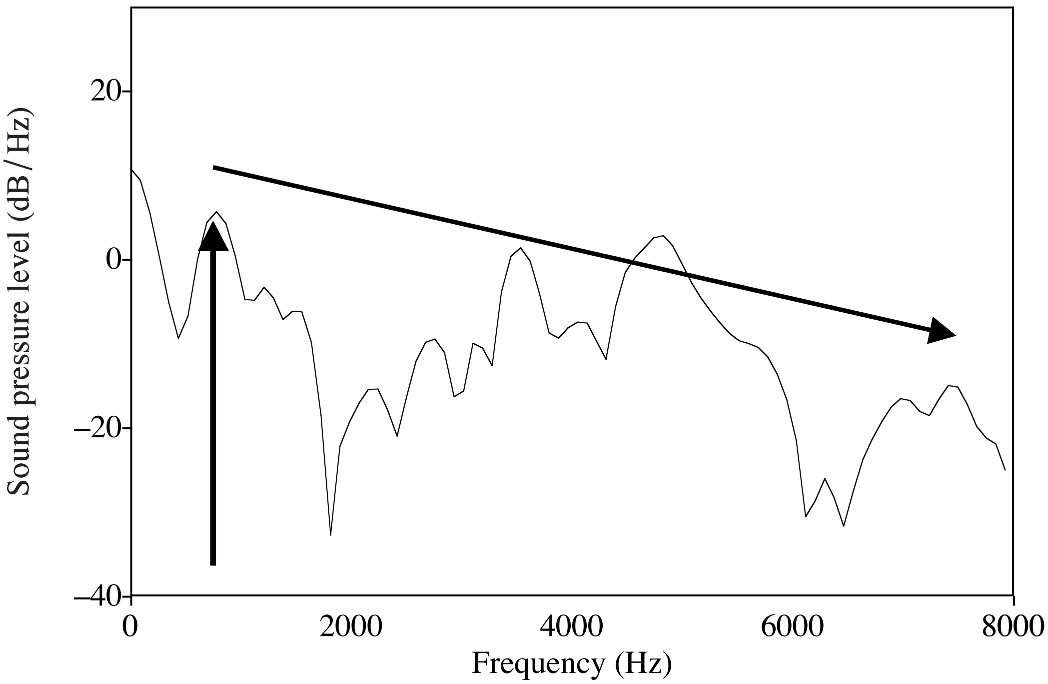


Figure 6-17.
Spectrum of [x] in ‘macabro’
(Subject M1, repetition 1)



Taking perceptual factors into account, we see that perception can account for place of articulation asymmetries in *Gorgia Toscana* in two ways. On the one hand, a constraint against perceptual confusion, given the existing phoneme inventory, likely inhibits lenition of non-velar consonants. On the other hand, the availability of salient place of articulation cues in the speech signal of fricatives means that lenited stops retain a three-way contrast with respect to each other, such that velar lenition does not result in perceptual confusion with non-velars with respect to place of articulation.

Perception on its own, however, cannot account for other patterns that emerge from the present study's data, particularly the gradient characteristic of *Gorgia Toscana*, the generalization of weakening to a natural class, and the intersubject variation in preference for /k/ lenition.

6.5 Featural approaches to lenition and Gorgia Toscana

A featural approach to Florentine weakening offers some of the explanatory power that is missing from production- and perception-oriented frameworks. First, it captures the natural classes of stops without regard to place of articulation. Second, it allows for the categorical behavior of underlying segments. It does not, without physiological, perceptual, and social stipulations, account for the varied weakening of consonants within a class or for intersubject variation.

There is historical evidence that the non-velar stops /p/, /b/, /t/, and /d/, all of which were present in early Italian's phonemic inventory, began leniting at least several generations after velar lenition was first observed. From the articulatory discussion above, lenition of these non-velars is less likely to be physiologically motivated than velar lenition. From the perceptual discussion, non-velar lenition is also more likely to be constrained than velar lenition is. Nevertheless, non-velar lenition *did* occur, and continues to occur, in Florentine Italian. The first question in this section is why such a spread should have occurred: why should phonetically motivated lenition of velars have propagated throughout the natural class of oral stops? The answer may be related to non-articulatory motivations: symmetry (Hayes 1999), phonologization (Hyman

1977) and exaggeration (Janda 2000; Janda and Joseph 2001). All of these concepts share a common theme: sound changes which begin as purely phonetic may become less so over time, and ultimately occur in the absence of the original conditioning environment.

Hayes (1999) argues that purely phonetic constraints, while being explanatorily powerful and influential to the phonology, are too complex to account for the actual patterns observed in languages:

> ...constraints are typically natural, in that the set of cases they ban is phonetically harder than the complement set. But the "boundary lines" that divide the prohibited cases from the legal ones are characteristically statable in rather simple terms, with a small logical conjunction of feature predicates. In other words, phonological constraints tend to ban phonetic difficulty in simple, formally symmetrical ways. (1999: 253-54)

Hayes illustrates this preference for simpler, feature-based constraints over direct physiological motivations by comparing allowable segments in Japanese and Arabic. He discusses two phonetic realities with respect to voicing difficulties – both voiced obstruent geminates and voiceless labial stops are physiologically difficult.[54] Japanese allows [pp] and bans [bb], while in Arabic the preference is exactly the opposite. If one outcome were (universally) phonetically more difficult than the other, and the phonology of a language mapped directly to this difficulty, we should not expect these languages to exhibit such a contradiction. Therefore, Hayes argues, the

[54] See Ohala (1983) for an explanation of the aerodynamic principles involved in these assessments of difficulty.

Japanese and Arabic bans should be viewed as general phonological constraints, either against voiced obstruent geminates or against voiceless labial stops (1997: 254), not as direct results of mapping the degree of phonetic difficulty to the languages' respective phonologies. While phonetic motivations play a role in the basis of constraints, their effects are militated by "some pressure toward formal symmetry" (1997: 254).

Hyman (1977) discusses phonologization as the process by which natural (i.e., phonetic or intrinsic) variations in the speech signal become part of a language's phonological system. At the phonologization stage of a sound change, a physiologically motivated perturbation is "exaggerated to a degree which cannot be attributed solely to universal phonetics" (1977: 410).

Janda (2000: 305) argues that "sound change tends to [remain] regular, not due to persistent influence from some kind of articulatory/acoustic phonetic naturalness, but instead because exaggerations and misperceptions of phonetic tendencies tend to involve stepwise generalizations based on the natural classes of phonology." How these exaggerations may be tied to social forces (Janda and Joseph, 2001) will be discussed in the section below.

Hayes's, Hyman's, and Janda and Joseph's explanations of non-phonetic conditioning in sound change can be extended to account for the historical patterns in *Gorgia Toscana*. Lenition of non-velars in Florentine Italian may involve a conceptual shift occurring subsequent to an initial pattern which is phonetically-conditioned, resulting in the generalization of a phonetic process to domains in which purely phonetic factors do not necessarily play a role. In this conceptual shift, feature-based phonology matters: it offers both a plausible motivation for the spread of lenition throughout the Italian stop series and a simpler set of rules of constraints.

The second advantage of a featural account is its ability to account for the categorical alternations that Articulatory Phonology cannot (Zsiga 1997: 229): "Any one representation that is powerful enough to describe gradient processes will not be constrained enough to explain the categorical nature of alternations...." The data in the current study, while attesting to the gradient nature of *Gorgia Toscana*, is also evidence that one segment, /k/, lenites categorically (at least some of the time). If /k/'s tendency towards deletion is not simply a tendency towards increasingly more reduction, but a categorical alternation, then a theory of gradient gestural reduction, as discussed in Section 6.2, does not account for its behavior. Rather, extreme weakening of /k/ might be part of the phonologization process described by Hyman (1977) or the regularization process described by Janda and Joseph (2001).

There are weaknesses, however, to a feature-based approach. While phonological features capture natural classes and define even single segments in terms of articulatory characteristics, the set of these features is limited. Such a limitation enables generalizations over sound-changing processes, but fails to account for three characteristics of the lenition data in this and previous studies: gradience, variation, and place-asymmetry.

Featural approaches without stipulative embellishments cannot handle gradient processes. Many appear as all-or-nothing categorizations of an outcome, as Nespor and Vogel's rule in Figure 6-18, and fail to account for the fine granularity and analog nature of lenition observed in the present study.

Figure 6-18.
Prosodic account of *Gorgia* (repeated)
Nespor and Vogel (1986: 207)

$$[\text{-cont}]\ [\text{-voi}] \rightarrow [\text{+cont}] / \ {}_{I}[\ldots[\text{-cons}]\ \_\_\_\ [\text{-cons}]\ldots]_{I}$$

The rule in Figure 6-18 states that all voiceless stops will fricativize between consonants (within the intonational phrase, when certain stress conditions are met, in a certain register, etc.). It does not allow for lenition beyond the stipulated alternation [-cont] → [+cont][55].

Nor do feature-based theories allow variation in the output. The simplest type of featural representation, like the rule in Figure 6-18 above, states that given the right prosodic context, lenition will occur *all of the time.* The data in the present study show that the application of *Gorgia Toscana* varies – it is not the case that all stops necessarily lenite, or lenite to the same extent, in allowable contexts.

Kirchner (1998) repairs the part of the variation problem by making specific reference to the allowance of different levels of articulatory effort in various speech registers (based on Giannelli and Savoia's 1978 observations). Raising or lowering the LAZY constraint's coefficient for any given speech register level results in a different

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[55] Nespor and Vogel's (1986) goal, however, was not to account for gradience in surface variants, but to examine the prosodic constraints on various sound-changing processes.

optimal output. In the tableau in Figure 6-19, LAZY is set at 75, allowing only segments with a lesser effort cost to surface.

Figure 6-19.
Weak position, level A (effort costs: p,t,k = 85; ɸ, θ, x = 70)
(Kirchner 1998: 274)

	LAZY$_{75}$	*-strid, +cont, +cons	PRES (cont)
p, t, k – p, t, k	* !		
☞ p, t, k - ɸ, θ, x		*	*

In the tableau in Figure 6-20, the same constraint is hypothetically changed to 90, and generates a different optimal output:

Figure 6-20.
HYPOTHETICAL level (effort costs: p,t,k = 85; ɸ, θ, x = 70)

	LAZY$_{90}$	*-strid, +cont, +cons	PRES (cont)
☞ p, t, k – p, t, k			
p, t, k - ɸ, θ, x		*	*

This account repairs the deficiencies of feature-based rules in accounting for variable output, but only by incorporating a phonetically grounded constraint. The constraint LAZY and its values at different levels, as well as the effort costs of various surface realizations, are motivated by articulatory difficulty.

Finally, although featural accounts which refer to entire natural classes are arguably simpler and well motivated, they do not explain the asymmetry among the members of a natural class that appear in this and previous studies. Even Kirchner's recent model does not fully and consistently differentiate places of articulation as more or less susceptible to lenition, as we see from the following tableaux.

Figure 6-21.
Spirantization of stops in weak position at level A
effort costs are: p,t,k=85; b,d,g=75; ɸ̞,θ̞,x̞=74; β̞,ð̞,ɣ=73
(Kirchner 1998:274-275, Tableaux 8-23 and 8-26 combined)

	PRES(crisp rel)	LAZY$_{75}$	*-strid, +cont, +cons	PRES(cont)
p t k – p t k	n/a	* !		
☞ p t k – ɸ̞ θ̞ x̞	n/a		*	*
g – g		*!		
☞ g – ɣ			*	*
☞ b d – b d				
b d – β̞ ð̞	*!			*

At this level, where speech is the slowest and most formal, all of the voiceless stops spirantize. Of the voiced stops, only /g/ does so because velar stops are underlyingly [-crisp release] and so their spirantization does not violate the highest ranked constraint.

In its current state (motivated by Giannelli and Savoia's 1978 discrete analysis of their data), Kirchner's analysis is both too broad and too narrow to account for the data in the present study. It is too broad in the sense that effort value assignments for stops do not vary by place of articulation. On the other hand, it is too narrow in that the addition of a single place-related constraint categorically rules out non-velar lenition at the rate and register levels where the constraint is incorporated. Both of these problems, relative to the present data, arise from the predominant role played by features and natural classes in the model. This is not so much a fault of Kirchner's model as it is a logical sequela of the discreteness of the data. It could easily be corrected by incorporating LAZY and faithfulness constraints that are articulatorily more fine-tuned and less dependent on abstract features and classes.

There is another reason to consider a phonological framework's explanatory capacity with respect to *Gorgia Toscana*. As mentioned previously, the data in the current study exhibits internally conditioned variation in degree and locus of lenition. Underlying forms lenite optionally and to different degrees, and some lenition appears to vary depending on prosodic contexts. For example, word- and foot-internal status had a positive effect on the weakening of non-velar segments, as discussed in Chapter 5. While a phonetic explanation fails to account for these aspects of variation because of its strict reference to articulators alone, phonology provides us with a wider set of tools. Optionality, or variation in degree, can be handled by expansions to Optimality Theory (Anttila 2002): the availability of several distinct grammars to a given individual (Multiple Grammars Model); the incorporation of ordered pairs of constraints into a single grammar (Stratified Grammar); or a non-discrete ranking system where constraints can overlap (Continuous Ranking). Variation in locus, where certain segments are affected by their prosodic context, can be explained by reference to non-physiological constructs like syllables, feet, morphemes, edges, and faithfulness in the formulation and ranking of constraints in any of the aforementioned models.

Despite the drawbacks of feature-based explanations for *Gorgia Toscana*, some incorporation of features seems necessary in light of *Gorgia's* eventual spread to an entire natural class of segments and the apparent tendency for voiceless velars to weaken categorically. The availability of, and reference to, a phonological grammar may also assist in accounting for variable output in terms of degree and locus of lenition. The inadequacy of phonological accounts, however, is in their inability to account for gradience, explain why velar segments are more susceptible to lenition, or explain why lenition of /k/ is suppressed or accentuated by some of the subjects in the current study.

6.6 Functional approaches

This section discusses the relationship between linguistic variation and social context as it relates to *Gorgia Toscana*. The role of social differentiation in language variation and change emerged from Labov's study of New York dialectal variation (Labov 1966). Labov explored the concept of social class as a variable, and this concept has been revisited throughout the development of sociolinguistic literature by Labov (1972, 1980) and many others including Trudgill (1974), Feagin (1979), and Horvath (1985). Social class, which can be described in terms of objective economic indicators or in terms of subjective notions of prestige and community membership (Ash, 2002), is not the only social variable, however. Trudgill (2002: 373) names three others that have a place in sociolinguistic research: social context (or style/register), gender, and ethnicity have all been used as independent variables in the attempt to explain linguistic variants in the domains of sound, form, and meaning. Variationist theories can be incorporated into a study such as the present one, which attests to diachronic spread of lenition and synchronic variation in individual subjects' lenition patterns.

Giannelli and Savoia (1978) have set a precedent for considering social factors as correlates and motivators of lenition. The small number of subjects in this study makes social generalizations difficult; however, social variables cannot be ignored. This section focuses on the role that social forces might be seen to play in the historical acceptance of lenition in the Florentine dialect, the subsequent spread of lenition to non-velars, and in the present-day variation in preference for velar lenition. There are sound reasons to believe that phonetic and phonological motivations play an essential role in the innovative and spreading stages of *Gorgia Toscana*, respectively, but these motivations cannot completely account for the diachronic observations, and they cannot account at all for the synchronic variation of velar lenition among subjects in the present study.

6.6.1 Social factors in the acceptance and spread of a sound change

While articulatory pressures may be the catalyst for the original innovation of velar lenition, its acceptance as a regular dialectal feature cannot be attributed only to phonetic conditioning. If it were, the presence of velar lenition in only one region of Italy would indeed be difficult to explain. Labov (1972: 3) begins his investigation into language change by stating "...one cannot understand the development of a language change apart from the social life of the community in which it occurs." Narrowing this view to the onset of change, he quotes Sturtevant (1947: 74-84):

> Before a phoneme can spread from word to word...it is necessary that one of the two rivals shall acquire some sort of prestige.

This observation may be important in the understanding of why velar-lenition, arguably a phonetically-motivated innovation that might have occurred in all of Italian, should have been adopted into certain dialects, such as Florentine.

Labov, while arguing strongly for the presence of social conditioning in language change, does not rule out the role of phonetics:

> At the first stage of change, where linguistic changes originate, we may observe many sporadic side-effects of articulatory processes which have no linguistic meaning: no socially determined significance is attached to them...Only when social meaning is assigned to such variations will they be imitated and begin to play a role in the language (1972: 23).

The overlay of social factors, then, is just that – a post-innovative force that does not in any way undermine the argument that velar lenition in Florentine occurred for phonetic, and only phonetic, reasons, a claim made by Janda and Joseph (2001: 205-206). Their "Big Bang" (Janda and Joseph's term) theory of sound change requires that "purely phonetic conditions govern an innovation."

Why did Florentines adopt the phonetically motivated innovation of velar lenition, and why has it spread throughout the natural class of stops? One plausible answer is that lenition became associated with being Florentine, and took on a specific social meaning, in much the same way as vowel centralization did on Martha's Vineyard:

> It is apparent that the immediate meaning of this phonetic feature is "Vineyarder." When a man says [rɐɪt] or [hɐus], he is unconsciously establishing the fact that he belongs to the island: that he is one of the natives to whom the island really belongs (Labov 1972 36).

As to the subsequent spread of lenition to other places of articulation, this generalization of a specific dialectal feature can also be rooted in social forces. Janda and Joseph (2001: 7-8) discuss Northeastern Swiss German vowel-lowering in this context, arguing that the extension of pre-rhotic lowering to environments preceding a wider range of consonants can be viewed "as a method of reinforcing local identities."

The present study was not set up as a sociolinguistic inquiry into *Gorgia Toscana*. There are, however, gaps in the scientific analysis that appear to require reference to aspects beyond those supplied in phonetic and phonological frameworks. While the role of social factors is not central to this study, it remains reasonable to view the weakening of consonants in the data as an innovation that took on a specific social meaning – that of being *Florentine* – and that this attachment of meaning, whether subconscious or conscious, was an ingredient in the adoption of lenition as a regular and generalized process. Present-day accounts of the ability of Italians to immediately identify a speaker as being from central Tuscany (Cravens 2000:14) may be seen as the felicitous result of speakers' self-marking via lenition.

6.6.2 Social factors in the variation of a sound change

As earlier chapters show, lenition in present-day Florentine is not regular. Although certain patterns emerge from testing a number of hypotheses, there is a great deal of intersubject and intrasubject variation. This section addresses one specific element of intersubject differences: the suppression of /k/ lenition among certain subjects in light of prior observations that velars are more prone to lenite and the general presence of lenited consonants in all subjects' speech.

Florentines are extremely conscious of their dialect and some of its phonetic, syntactic, and lexical features, but they appear to be more aware of /k/ lenition than of /t/ and /p/ lenition (Cravens 2000: 14). The result of this consciousness, Cravens claims, is a Labovian stereotype, where the velar surface variant [h] serves as a "sociolinguistic marker or indicator of *toscanità* 'Tuscanness'." (Cravens 2000:14). This stereotype is regarded both positively and negatively both by the speakers it marks, and by other speakers throughout the Italian peninsula. Indeed, Cravens points out the typical non-Tuscan mimicry of [uːna hɔːha hɔːla hon la hanːutʃːa] *una Coca Cola con la cannuccia* 'a Coca Cola with a straw' (Cravens 2000:14)[56]. Given the potential of negative marking of /k/ lenition with respect to a greater geo-political area, another sociolinguistic marker is plausible: the realization of unlenited /k/ as an indicator of 'Italianness.'

[56] Craven's observation is exactly right: I personally have heard this phrase throughout Italy in discussions of Florence and Florentines, even when the discussion is not language-related.

Although there is a sense in which dialectal features in Italy are linked with lower rungs of the social ladder, not all such features need be regarded pejoratively:

> The distinction between Italian and dialect has no firm correlation with social hierarchy, because although ignorance of Italian is limited to the bottom of the scale, the use of dialect is not, and cuts right across class barriers. (Lepschy and Lepschy 1977: 12)

Izzo (1972: 100) corroborates this observation with anecdotal evidence based on a year's worth of interactions with university students, a university professor, and various other business people and professionals in Florence.

These allusions to lenition as both a positive and negative social marker are reflected in the various attitudes of Florentine Italians. On the one hand, the majority of the subjects interviewed for the present study, and of other Florentines interviewed, regard their most salient dialectal feature – *la "c" aspirata*[57] – as a deficiency, claiming that it is *sbagliata* 'incorrect.' On the other hand, regular adoption of this dialectal feature by non-native speakers of Italian is looked upon favorably, and scholarly work on *Gorgia Toscana* is considered a tribute to, rather than a derogatory illumination of, Florentine speech. There appears to be a conflict, then, on the part of speakers in the community: they are conscious of their /k/ lenition and view it as a deviation from the ideal linguistic standard while also viewing lenition as a positive marker of identification with Florence.

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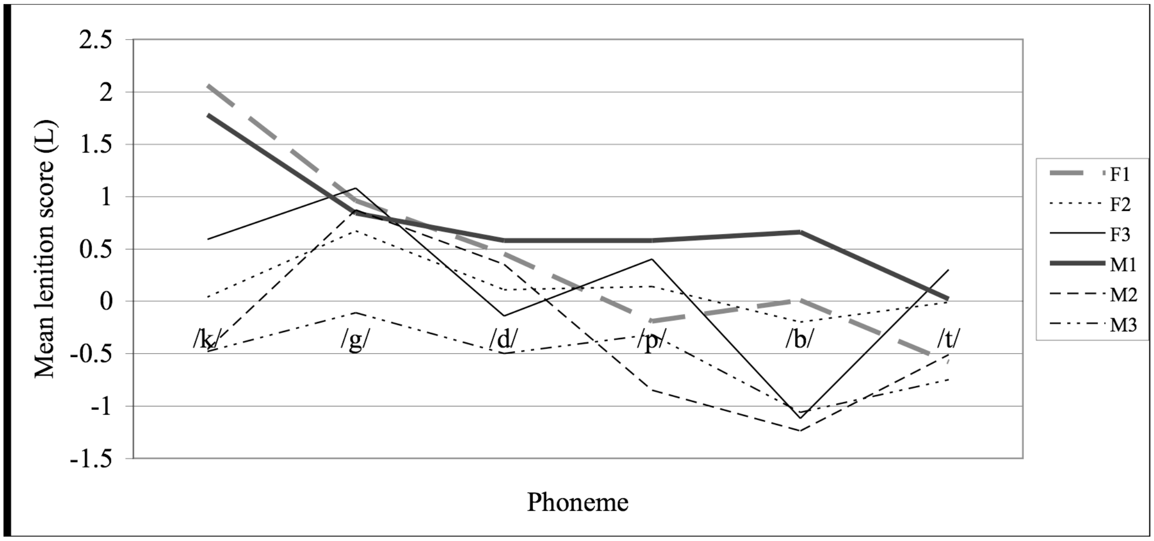
[57] In other words, lenition of /k/. Florentines untrained in linguistics generally refer to stop consonant lenition as "aspiration" and are referring to the orthographic representation of the voiceless velar stop.

Although this study's original design did not incorporate the issue of variation in preference for /k/ lenition, there is a plausible sociolinguistic explanation for the tendency of certain speakers to suppress the dialect stereotype. As Cravens points out (2000: 13), the pronunciation of full occlusives corresponds to Standard Italian and is overtly prestigious. Thus we might expect those Florentines who have regular contact with non-Tuscans to be somewhat more inclined towards use of the national norm, which involves /k/ surfacing as [k]. Schilling-Estes (1999), following Trudgill (1986) posits that dialect dissipation stems directly from increased contact with speakers of other language varieties. This hypothesis can be extended to the present discussion. On the basis of personal data collected from the six subjects in this study, /k/ lenition is less likely to occur in the speech of individuals (F2, F3, M2, and M3) with generally higher educational levels, or who have some combination of regular business dealings with colleagues and clients throughout Italy (and in three cases, throughout Europe). The dialect stereotype is least suppressed, and possibly accentuated, by the two subjects (F1 and M1) who maintain virtually no contact with non-Florentines. The intersubject variation graph from Chapter 5 is reproduced here to illustrate this pattern. Consistent with the measurement of lenition in previous chapters, higher *mean lenition scores* indicate more lenition.

Figure 6-22.
Inter-subject variation in segment lenition



Further questions arise from the intersubject patterns in this study. Following Bucholtz (1999), we might assume that the behavior of speakers is agentive in nature (à la Certeau 1984), and not simply a subconscious reflection of social patterns already in existence (à la Bourdieu 1991). It is not immediately clear whether speakers are engaging in negative or positive identity practices (Bucholtz 1999: 211-212), but the patterns in Figure 6-22 indicate that speakers may be using phonetic information to build and convey identity, and so are engaging in some type of identity practice. If this is indeed the case, we can likely use *Gorgia Toscana* data to explore what the exact nature of that identity is (Tuscanness, Italianness, or their antitheses) and the extent to which different speakers build this identity in varying contexts.

The role of social forces, at once encouraging the continuation of lenition in a more general form and causing individual speakers to either accentuate or suppress lenition, has not yet been explored in the study of the *Gorgia Toscana*. While the present experiment cannot address this subject more fully, it has nonetheless brought to light an interesting and testable area of inquiry that has a basis in the literature on dialectal variation and the use of phonetic information in the construction of social identity.

6.7 Phonetic, phonological, and social forces as filters

This chapter has attempted to answer a number of questions concerning lenition in Florentine Italian, repeated here.

(1) Why might both voiced and voiceless velars exhibit special status diachronically, and, in many cases, synchronically, in this sound-changing process?

(2) How can gradience in the surface manifestations be accounted for?

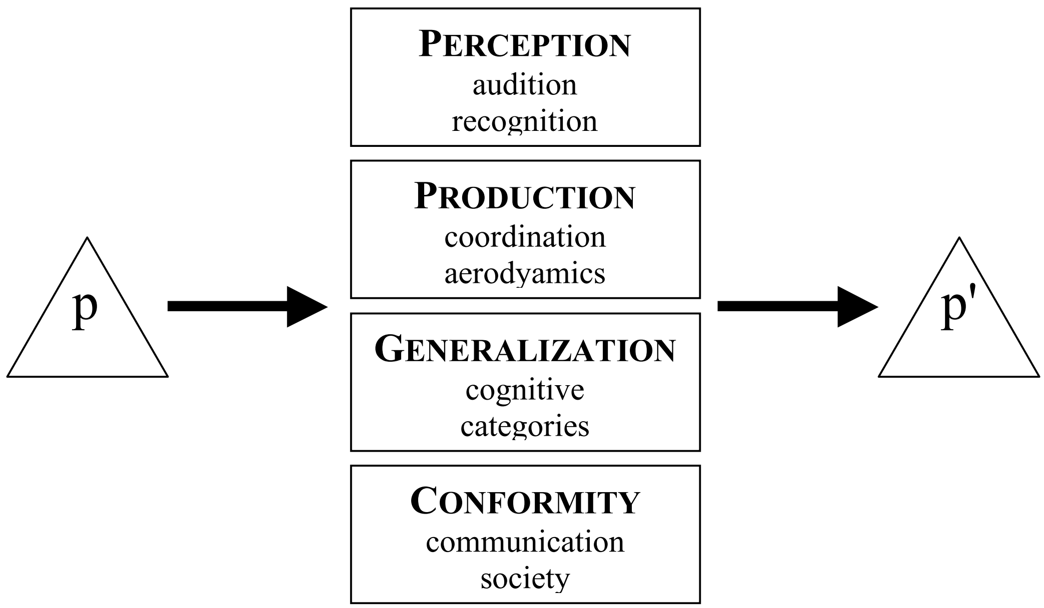
(3) Why did non-velars eventually become (and why do they continue to be) susceptible to the process?

(4) Why does the voiceless velar /k/ show a tendency towards categorical extreme weakening?

(5) How can intersubject variation, particularly with reference to the preference or dispreference of velars, be explained?

As we have seen, these questions are best addressed by reference to various forces acting to either encourage or inhibit lenition. Hume and Johnson (2001) refer to these forces as filters, and suggest they play independent, and sometimes antagonistic, roles in mapping a cognitive representation *p* onto a different cognitive representation *p'* (the relationship between *p* and *p'* representing sound change and necessarily being bidirectional). The model proposed by Hume and Johnson is in Figure 6-23.

Figure 6-23.
Filters involved in sound change
(Hume and Johnson 2001: 16)



In order to implement this model, Hume and Johnson propose 1) an interaction among the four filtering forces, and 2) the dependence of these forces on an individual language's existing sound system. These buy us variation and language-specificity, respectively. In other words, the independent filters of production, perception, generalization, and conformity work to generate *p'* from *p* in different, and often opposing ways, sometimes resulting in a type of backlash that subsequently reverts to *p*.

The change from *p* to *p'* and vice-versa occurs within a finely-grained time scale, surfacing as synchronic variation of the type observed in *Gorgia Toscana*, but not ruling out historical patterns occurring over larger stretches of time.

The model also takes into account the fact that an existing cognitive representation *p* is but one part of a larger group of *p*'s in any given language's phonological system. The filtering forces, then, work to mutate *p*, but not without reference to the larger system unique to a specific language. In this way, even if we suppose identical filters, the mapping of *p* to *p'* will not necessarily result in an identical change cross-linguistically – particularly given the near impossibility of the CONFORMITY (sociolinguistic) filter acting in the same way across all languages or dialects.

Taking the patterns observed in a process like *Gorgia Toscana*, and the various forces that either condition or constrain them, Hume and Johnson's model seems to be exactly the type of interactive system needed to account for the process under investigation. We have seen that *Gorgia Toscana* involves reference to articulatory, perceptual, featural, and social factors, some of which work cooperatively, and some antagonistically. Velar lenition is encouraged by articulatory factors, neutrally affected by perceptual factors, phonologized by generalization factors, and either suppressed or encouraged by social factors. Non-velar lenition, on the other hand, is neutrally affected by articulatory factors, constrained by perceptual factors, encouraged by generalization factors, and probably not affected at all by social factors. The overall pattern that emerges is that the filters in Hume and Johnson's model favor velar lenition to a greater extent than non-velar lenition, as the representations in Figure 6-24 and Figure 6-25 illustrate.

Figure 6-24.
Abstract representation of /k/ - [x] alternation

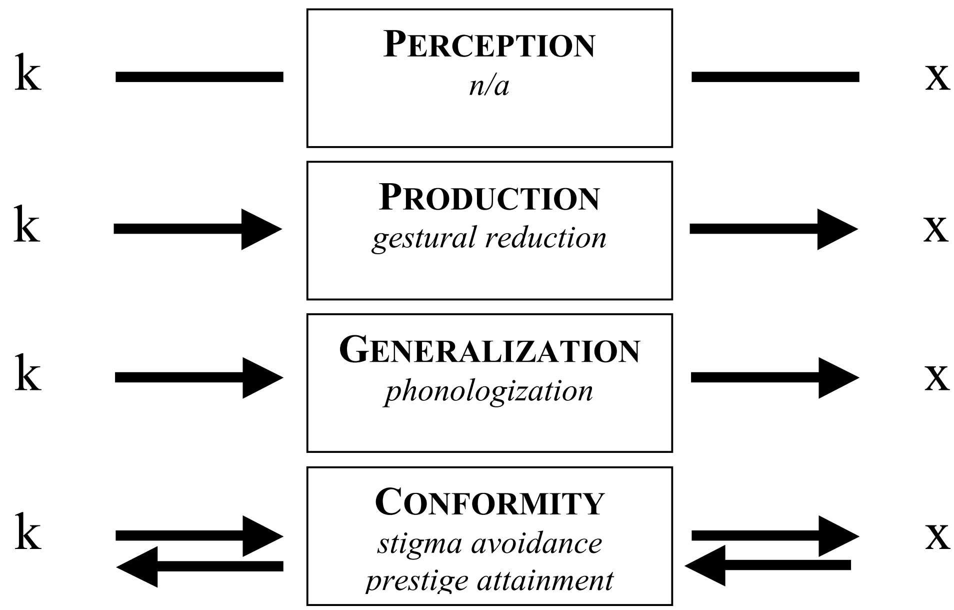
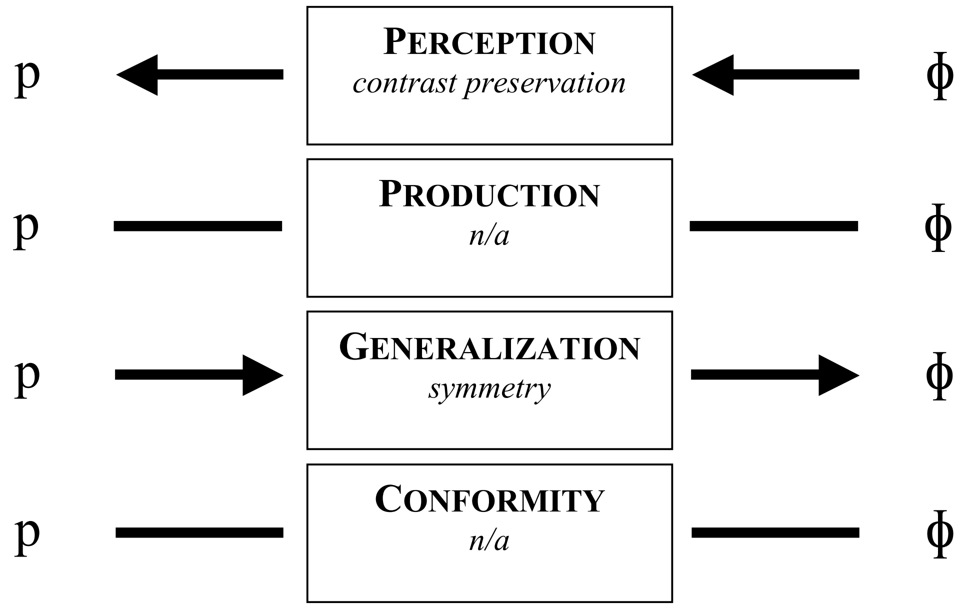


Figure 6-25.
Abstract representation of /p/ - [ɸ] alternation



The abstract representations of the /k/-[x] and /p/-[ɸ] alternations do not include any weightings of the individual filters, a feature that must be included, and able to change over time, in order to account for the variation observed in the process. They do, however, generalize over the observed patterns in *Gorgia Toscana* in a way that is both descriptively and explanatorily adequate, and provide us with a mechanism that incorporates interactions among the independent forces involved in the sound change process under investigation.

6.8 Evaluation

6.8.1 Limitations and directions for future research

The small number of subjects in the present study limits statistical analysis and makes some generalizations difficult. This number, however, could be increased substantially in future experiments without concomitantly increasing the number of tokens. Since the analysis of nasal and geminate segments proved problematic and inconclusive, future studies could be limited to oral singletons. Even the tokens including these segments could be trimmed to include only word-internal consonants with identical lexical frequency, stress, and flanking vowels, as the present study's findings indicate that none of these variables plays a significant role in lenition.

Speech will differ depending on the naturalness, or unnaturalness, of its surroundings (Feagin, 2002: 26). All of the speech collected for the present study consisted of subjects' reading of sentences that were carefully constructed by the investigator (a non-native speaker of Italian), and recordings were made in a quiet environment with equipment that was conspicuously present. Furthermore, the subjects were aware that Florentine speech was a central element to the study, because they were required to sign informed consent documents in which the study's general goal was clearly stated. For these reasons, this study is tainted by Labov's (1972a: 61) Observer's Paradox: "our goal is to observe the way people use language when they are not being observed." All of these facts contributed negatively to the naturalness of the subjects' speech and resulted in a more formal speech style than if the recordings had been made in an informal environment with little or no intrusion by an investigator and her technical apparatus.

Objective acoustic analysis will always necessitate certain environmental drawbacks, but future work in this area can certainly minimize these. Limiting the token set to high-frequency lexical items in common prosodic settings will eliminate the need of sentence lists, and a less formal interview technique like the map-task or narrative-inducing questions will very likely provide a consistent token pool across subjects. Experimentation with acoustic effects of omni-directional microphones may result in a less-intrusive recording technique without compromising recording quality. It may be impossible to completely overcome the Observer's Paradox, but a modified experiment can certainly move in that direction.

6.8.2 The present study's accomplishments

This study is the first acoustically based theoretical explanation of the lenition process known as *Gorgia Toscana*. Previous accounts have been limited in that they exclude acoustic analysis entirely or make no attempts to reach beyond acoustic descriptions to offer an explanatory analysis in light of currently available theoretical frameworks. Furthermore, the majority of published work[58] on *Gorgia Toscana* has been written in Italian and confined to Italian linguistic journals, making it far less

[58] The work by Cravens (1998, 2000) and Kirchner (1998, 2001, 2004) that focuses heavily on *Gorgia Toscana* relies almost exclusively on the data collected by Giannelli and Savoia in their 1978 study.

accessible to linguists outside the Italian community of scholars. This dissertation therefore fills several independent gaps in the literature.

First, the study has gathered an extensive set of speech data that incorporates rigid controls relevant to the specific lenition process under investigation. Second, it has provided a detailed, consistent, acoustic and statistical analysis of all six oral stops undergoing lenition in Florentine. This analysis builds on previous work by Marotta (2001) and Sorianello (2001). Third, it has reached beyond description of the data and offered theoretically grounded explanations of several patterns arising from the data analysis. Finally, the analysis extends beyond the confines of *Gorgia Toscana* and offers general support for the interaction of phonetic, phonological, and social factors in the study and explanation of sound-changing processes.

The present study has also made a significant methodological contribution. Its use of Principal Components Analysis demonstrates the ability to extract a variable that has no single phonetic correlate. In this case, the variable is lenition, although the same method of latent variable extraction may prove helpful to laboratory phonologists and phoneticians when studying constructs such as breathiness, laryngealization, sonority, or nasality – all of which entail multiple phonetic indicators.

6.9 Conclusion

This dissertation is the first step towards a thorough account of consonant lenition in Florentine Italian and the multiple factors that influence it. It has provided a detailed review of the process known as *Gorgia Toscana* and of the existing literature treating the process. It contains a set of speech data relevant to *Gorgia Toscana* that incorporated specific controls. The analysis of the data introduced a method for quantifying gradient output, thus simplifying statistical work when several independent variables are involved. The data allowed an extensive description of the factors involved in this specific lenition process, and an analysis of the explanatory power of phonetic, phonological, and variationist frameworks.

This type of integrated treatment of linguistic facts has become more appealing recently, as we begin to acknowledge that responsible scientific inquiry must include an examination of multiple aspects of actual data:

> We should be pursuing a view of language and linguistics that is as encompassing and integrative as possible…Theories should be designed to have utility in accounting for both language structure and language use. (Guy 1997: 141)

It is hoped that the specific observations derived from the present study will further stimulate inquiry in to the roles played by physiological, perceptual, featural, and social factors in sound-changing processes. The data herein suggest a need for articulatory and perceptual studies of weakening in Florentine. They also indicate that more investigation is warranted into the role that phonological constructs such as symmetry and prosody play. The variable nature of consonant weakening suggests the usefulness of this data in future research on variation, particularly in the domain of sound change, and indicates that a greater understanding of how sound alternations are socially marked is called for.

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Appendix A - Subject information

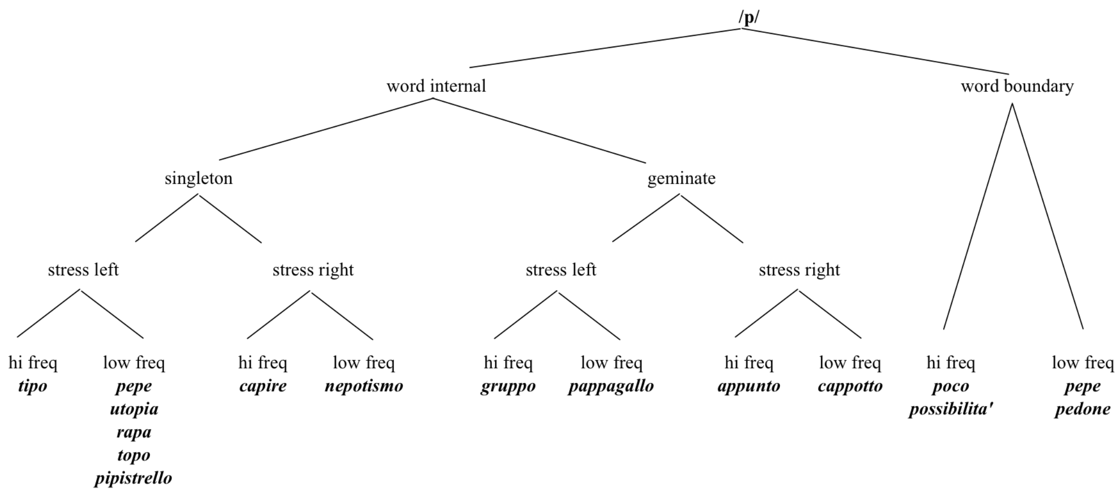
ID	Sex	Age	Occupation	Relationship to investigator	Education	Lived outside Florence	L2 proficiency
F2	F	54	Art gallery employee	Acquaintance since 2001	Superiore	Never	English 2
F3	F	41	Director of didactics, Italian school	Colleague and friend since 2003	Laurea, specializzazione	3 mos. Spain	Spanish 4 English 2.5
F1	F	60	Maid	Close friend since 2001	5th element	Never	None
M3	M	42	Antique store owner	No relationship	Media	Never	Spanish 2.5 English 1.5 Portug 1.5
M2	M	66	Retired business owner	Close friend since 2001	Laurea	1 mo. Torino	French 4 Spanish 3 English 2
M1	M	69	Retired laborer	Acquaintance since 2001	Media	Never	None

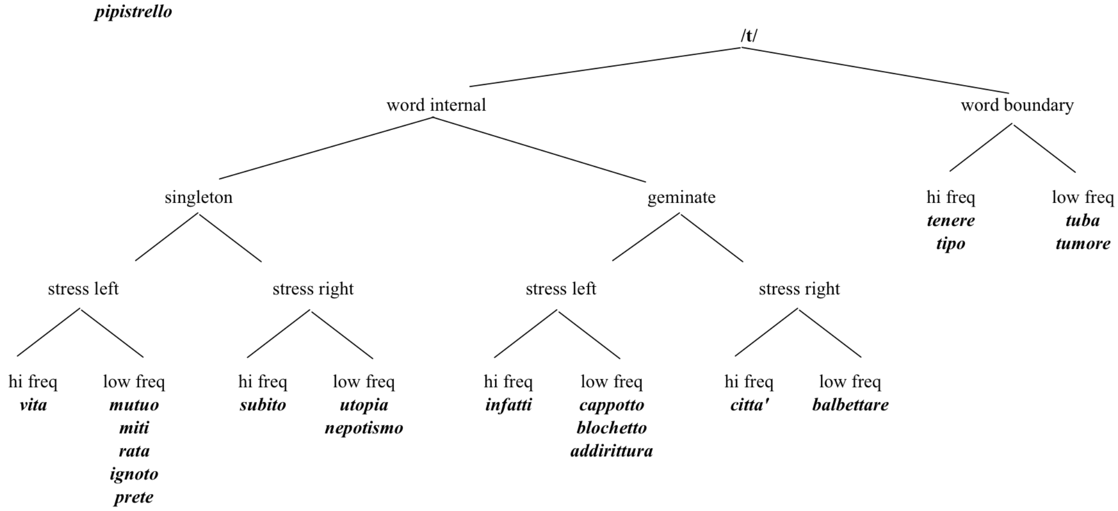
Appendix B - Independent variable and token trees

Note: These trees show the independent variables used in the proposed experiment and the corresponding tokens. A "-" signifies that no appropriate tokens are available for a particular set of independent variables.

Variables:

phonemes:	p,t,k,b,d,g
position:	word internal, word boundary
length:	singleton, geminate
stress:	left of phoneme, right of phoneme
frequency:	high, low

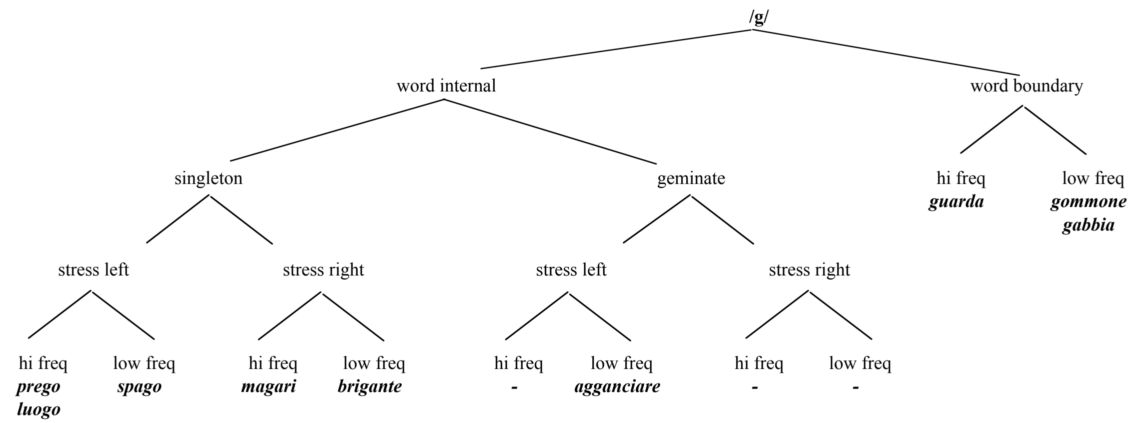




- /k/
  - word internal
    - singleton
      - stress left
        - hi freq: ***poco***
        - low freq: ***bica***, ***macabro***, ***cuoco***, ***fichi***, ***me'che***
      - stress right
        - hi freq: ***secondo (P)***
        - low freq: ***bucolico***
    - geminate
      - stress left
        - hi freq: ***macchina***
        - low freq: ***macchia***
      - stress right
        - hi freq: ***gnocco***
        - low freq: ***blocchetto***
  - word boundary
    - hi freq: ***chiama***, ***capire***
    - low freq: ***cabina***, ***contrabbando***, ***cappotto***

- /b/
  - word internal
    - singleton
      - stress left
        - hi freq: ***subito***
        - low freq: ***tuba***
      - stress right
        - hi freq: ***possibilita'***
        - low freq: ***cabina***
    - geminate
      - stress left
        - hi freq: ***abbastanza***
        - low freq: ***gabbia***
      - stress right
        - hi freq: **-**
        - low freq: ***contrabbando***
  - word boundary
    - hi freq: ***bene***, ***bisogna***
    - low freq: ***bucolico***, ***bico***

- /d/
  - word internal
    - singleton
      - stress left
        - hi freq: ***modo***
        - low freq: ***fodera***
      - stress right
        - hi freq: ***vedere***
        - low freq: ***pedone***
    - geminate
      - stress left
        - hi freq: **-**
        - low freq: **-**
      - stress right
        - hi freq: ***addirittura***
        - low freq: **-**
  - word boundary
    - hi freq: ***domani***, ***donna***
    - low freq: ***dannoso***


/g/
word internal
word boundary
singleton
geminate
hi freq
guarda
low freq
gommone
gabbia
stress left
stress right
stress left
stress right
hi freq
prego
luogo
low freq
spago
hi freq
magari
low freq
brigante
hi freq
-
low freq
agganciare
hi freq
-
low freq
-

Appendix C - Token list

Notes: Underlined segments in each token indicate the relevant sounds. Frequency and usage coefficients are from the De Mauro corpus "Lessico di frequenza dell'italiano parlato" (Corpus LIP). Glosses are from Il Grande Dizionario Hazon di Inglese 2005 (Garzanti).

Token	IPA	Freq	Use	Gloss
abbastanza	[ab.ba.ˈstan.tsa]	145	135	adv: sufficiently
addirittura	[ad.di.rit.ˈtu.ra]	101	85	adv: absolutely
agganciare	[ag.gan.ˈtʃa.re]	1	0	v: to clasp (inf)
appunto	[ap.ˈpun.to]	464	344	adv: exactly
balbettare	[bal.bɛt.ˈta.re]	1	0	v: stammer, babble (inf)
bene	[ˈbe.ne]	1633	1086	adv: well
bica	[ˈbi.ka]	1	0	n: heap, stack
blocchetto	[blɔk.ˈkɛt.to]	1	0	n: block (of wood)
brigante	[bri.ˈgan.te]	1	0	n: bandit
bucolico	[bu.ˈko.li.ko]	1	0	adj: bucolic
cabina	[ka.ˈbi.na]	2	0	n: booth
capire	[ka.ˈpi.re]	125	99	v: to understand (inf)
cappotto	[kap.ˈpɔt.to]	1	0	n: overcoat
chiama	[ki.ˈa.ma]	179	162	v: to call (3p sing)
citta'	[tʃit.ˈta]	131	76	n: city
contrabbando	[kɔn.trab.ˈban.do]	1	0	n: contraband

cuoco	[ˈkwuo.ko]	1	0	n: cook
dannoso	[danˈno.zo]	1	0	adj: harmful
domani	[do.ˈma.ni]	263	111	adv: tomorrow
donna	[ˈdɔn.na]	106	79	n: woman
fichi	[ˈfi.ki]	1	0	n: figs
fodera	[ˈfo.de.ra]	1	0	n: lining
gabbia	[ˈgab.bja]	1	0	n: cage
gnocco	[ˈɲɔk.ko]	1	0	n: blockhead
gruppo	[ˈgrup.po]	136	89	n: group
guarda	[ˈgwar.da]	341	219	v: to look at (3p sing)
ignoto	[iɲ.ˈɲo.to]	1	0	adj: unknown
infatti	[in.ˈfat.ti]	433	317	conj: in fact
macabro	[ˈma.ka.bro]	0	0	adj: macabre
macchia	[ˈmak.kja]	1	0	n: stain
macchina	[ˈmak.ki.na]	107	73	n: machine/automobile
magari	[ma.ˈga.ri]	215	181	adv: maybe
miti	[ˈmi.ti]	2	0	n: myths
modo	[ˈmo.do]	382	314	n: manner
mutuo	[ˈmu.two]	2	0	n: loan
nepotismo	[ne.po.ˈti.zmo]	1	0	n: nepotism
pappagallo	[pap.pa.ˈgal.lo]	2	0	n: parrot

pedoni	[pe.ˈdo.ni]	1	0	n: pedestrians
pepe	[ˈpe.pe]	2	0	n: pepper
pipistrello	[pi.pi.ˈstrɛl.lo]	1	0	n: bat
poco	[ˈpo.ko]	175	149	adj: not much
possibilita'	[pɔs.si.bi.li.ˈta]	130	96	n: possibility
prego	[ˈpre.go]	26	16	int: you're welcome
prete	[ˈpre.te]	2	1	n: priest
rapa	[ˈra.pa]	1	0	n: turnip
rata	[ˈra.ta]	2	0	n: installment
secondo (Pz)	[se.ˈkɔn.do]	264	219	prep: in accordance with
spago	[ˈspa.go]	1	0	n: string
subito	[ˈsu.bi.to]	164	140	adv: immediately
tenere	[te.ˈne.re]	36	24	v: to hold (inf)
tipo	[ˈti.po]	285	241	n: type
topo	[ˈto.po]	3	0	n: mouse
tuba	[ˈtu.ba]	1	0	n: tuba
tumore	[tu.ˈmo.re]	3	0	n: tumour
utopia	[u.to.ˈpi.a]	2	0	n: utopia
vedere	[ve.ˈde.re]	352	308	v: to see (inf)
vita	[ˈvi.ta]	247	159	n: life

APPENDIX D - SENTENCE LIST WITH EMBEDDED TOKENS AND ENGLISH GLOSSES

1. Secondo quella donna, a Viareggio si sta abbastanza bene.
   According to that woman, one is pretty happy in Viareggio.

2. Antonio Gramsci fu addirittura imprigionato e mori' in carcere senza poter ritornare a casa e vedere i suoi figli.
   Antonio Gramsci was really imprisoned and died in jail without being able to return home and see his children.

3. Oggi nei giornali si dice che l'Italia rischia di non agganciare i salari al costo della vita.
   Today in the newspapers it said that Italy is at risk of not being able to link salaries to the cost of living.

4. Infatti conosco una signora che sta a Londra ormai da quindici anni.
   In fact I know a lady who has now been in London for fifteen years.

5. Dice appunto che il rapporto est- ovest e' molto antico
   It says exactly that the relationship between east and west is an old one.

6. Ho detto che nemmeno io posso capire se continui a balbettare cosi'!
   I said that even I can't understand you if you continue to babble like that!

7. Sembrava molto bucolico quel panorama con la bica di fieno la' in fondo.
   It seemed very bucolic, that panorama with the stack of hay there in the background.

8. Bisogna vedere se c'e' la possibilita' di noleggiare una macchina domani.
   It's necessary to see if there's the possibility of renting a car tomorrow.

9. Il falegname ha adoperato un blocchetto di rinforzo.
   The carpenter has used a reinforcing block.

10. La locanda si chiama "Bastian Contrario" in onore di un vecchio brigante piemontese.
    The inn is called "Bastian Contrario" in honor of an old Piedmontese brigand.

11. Accanto alla cabina di telefono c'e' un gruppo di venti pedoni.
    Next to the telephone booth there's a group of twenty pedestrians.

12. Stamane ho trovato una macchia rossa sul mio cappotto.
This morning I found a red stain on my coat.

13. La vita in quella citta' fu descritto nel libro ignoto di Matilda Serao.
Life in that city was described in the unknown book by Matilda Serao.

14. Sara' molto dannoso tenere alla frontiera questa roba di contrabbando.
It will be very dangerous to have that contraband stuff at the frontier.

15. Ieri sera in cucina il cuoco ha trovato un topo mangiando i fichi.
Yesterday evening in the kitchen the cook found a mouse eating the figs.

16. Magari andro' domani a comprare una nuova fodera.
Maybe I'll go tomorrow to buy a new pillowcase.

17. Perche' mi guarda cosi' questo pappagallo nella gabbia accanto a te?
Why does it look at me like that, this parrot in the cage next to you?

18. Lo Gnocco di Verona e' un'antica tradizione carnevalesca e mia mamma sa il modo da farlo.
'Gnocco di Verona' is an old carneval tradition and my mom knows the way to make it.

19. Domani c' ho il mio magazzino da sistemare e devo metter a posto il gommone.
Tomorrow I have to get my shop in order and I need to put the little rubber boat where it belongs.

20. La tuba non e' uno strumento addatto per suonare l'inno nazionale.
The tuba is not a very appropriate instrument to play the national anthem on.

21. Quel film sul pipistrello è propio macabro.
That film about the bat is really macabre.

22. Secondo i miti grechi, la Medusa sembrava di essersi fatta le mèche.
According to the Greek myths, the Medusa looked like she streaked her hair.

23. Questo mutuo va pagato fra poco tempo.
This mortgage needs to be paid soon.

24. Credo che non la si potrebbe accusare di nepotismo.
I believe that one can't accuse her of nepotism.

25. Una rapa e un po' di pepe faranno insaporire il brodo.
A little pepper is needed to season the broth.

26. Ti prego di farmi sapere la risposta subito.
I beg you to let me know the answer soon.

27. La rata annuale che riceve il prete non è molto.
The annual installment that the priest receives isn't very much.

28. La rogna auricolare e' piu' dannosa per i cani che i tumori.
Auricular mange is more dangerous to dogs than cancer.

29. Secondo mia mamma, a Viareggio si sta abbastanza bene.
According to my mom, one is pretty happy in Viareggio.

30. Per tracciare una linea diritta si puo' utilizzare uno spago.
To trace a straight line one can use a string.

31. Questo tipo di tavolino e' molto adatto per il tinello.
This type of table is very appropriate for the little dining room.

32. Un'utopia globale di pace mondiale viene spesso vista come una delle possibili fini della storia.
A global utopia of world-wide peace is often seen as one of the possible ends to this story.

33. Insomma, il furto e' stato arrestato e ha detto dove si era nascosto la famosa mummia egiziana.
In conclusion, the thief was arrested and said where the famous Egyptian mummy had been hidden.

APPENDIX E - LIST OF UNMEASURABLE TOKENS

ID	Subject	Test word	VCV seq.	Freq.	Phoneme	Allophone
661	F1	secondo	/eko/	264	/k/	Weak approximant
693	F1	capire	/oka/	125	/k/	Weak approximant
703	F1	capire	/oka/	125	/k/	Weak approximant
709	F1	bica	/ika/	1	/k/	Weak approximant
783	F1	cappotto	/oka/	1	/k/	Weak approximant
788	F1	cappotto	/oka/	1	/k/	Weak approximant
793	F1	cappotto	/oka/	1	/k/	Weak approximant
809	F1	contrabbando	/iko/	1	/k/	Weak approximant
815	F1	contrabbando	/iko/	1	/k/	Weak approximant
821	F1	contrabbando	/iko/	1	/k/	Weak approximant
823	F1	cuoco	/woko/	1	/k/	Weak approximant
825	F1	fichi	/iki/	1	/k/	Weak approximant
828	F1	fichi	/iki/	1	/k/	Weak approximant
829	F1	cuoco	/woko/	1	/k/	Weak approximant
831	F1	fichi	/iki/	1	/k/	Weak approximant
891	F1	poco	/oko/	175	/k/	Weak approximant
894	F1	poco	/oko/	175	/k/	Weak approximant
940	F1	secondo	/eko/	264	/k/	Weak approximant
946	F1	secondo	/eko/	264	/k/	Weak approximant
1341	M1	capire	/oka/	125	/k/	Weak approximant
1346	M1	capire	/oka/	125	/k/	Weak approximant
1351	M1	capire	/oka/	125	/k/	Weak approximant
1405	M1	chiama	/ikja/	179	/k/	Weak approximant
1441	M1	cappotto	/oka/	1	/k/	Weak approximant
1469	M1	contrabbando	/iko/	1	/k/	Weak approximant
1479	M1	fichi	/iki/	1	/k/	Weak approximant
1539	M1	poco	/oko/	175	/k/	Weak approximant
1542	M1	poco	/oko/	175	/k/	Weak approximant
517	F3	guarda	/igwa/	341	/g/	Weak approximant
521	F3	guarda	/igwa/	341	/g/	Weak approximant
525	F3	guarda	/igwa/	341	/g/	Weak approximant
675	F1	vedere	/ede/	352	/d/	Weak approximant
714	F1	bucolico	/obu/	1	/b/	Weak approximant
733	F1	vedere	/ede/	352	/d/	Approximant
735	F1	possibilita'	/ibi/	130	/b/	Approximant
753	F1	brigante	/iga/	1	/g/	Weak approximant

ID	Subject	Test word	VCV seq.	Freq.	Phoneme	Allophone
838	F1	magari	/aga/	215	/g/	Weak approximant
951	F1	spago	/ago/	1	/g/	Weak approximant
1156	M2	magari	/aga/	215	/g/	Weak approximant
1171	M2	gabbia	/aga/	1	/g/	Weak approximant
1175	M2	gabbia	/aga/	1	/g/	Weak approximant
1369	M1	possibilita'	/ibi/	130	/b/	Weak approximant
1374	M1	vedere	/ede/	352	/d/	Weak approximant
1482	M1	fodera	/ode/	1	/d/	Weak approximant
1562	M1	subito	/ubi/	164	/b/	Weak approximant
1568	M1	subito	/ubi/	164	/b/	Fricative