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Diphthongization in Brazilian Portuguese

by

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ABSTRACT

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The goal of this dissertation is to increase our understanding of language variation and change by examining a particular case of linguistic variation in Rio de Janeiro. Diphthongization of back vowels before word final /s/ in words like *mas* "but" is a commonly noted feature of the Portuguese spoken in Rio de Janeiro. This leads to a potential merger of /a/ and /ai/ in this environment, such that *mas* is homophonous with *mais* "more." Diphthongization is examined as a conditioned sound change, and it is shown that phonetic environments that favor large formant transitions also tend to favor diphthongization, both historically and in synchronic variation.

Although both /a/ and /ai/ are fully diphthongal before word final /s/ for nearly all speakers in Rio, some differentiate them by fronting and/or raising the onset of /a/. This fronting and raising appears to be a change in progress for the word *mais*, with younger speakers in the working and middle classes having the most advanced tokens on average. In addition, young female speakers appear to be leading the fronting and raising of the *mas* onset. The vowel /a/ was also examined before non word final /s/ and /z/ (eg. *passa* "pass") for comparison. Although /a/ in this environment is more monophthongal than /a/ and /ai/ in the pre-word final /s/ environment, it does show signs of diphthongization, again with young, working class females leading the change. These correlations are similar to those found for sound changes in many other societies, though this is the first time they have been noted in Brazil.

Perceptual data on minimal pairs like *mas* and *mais* show a lack of symmetry

between production and perception, with some speakers producing a distinction that they do not claim to perceive. At first glance, this suggests a case of a near merger. However, upon closer examination, it appears that lexical diffusion is a better explanation for the patterns found in the data. Specifically, words with a higher frequency of usage tend to show more fronting and raising of the vowel than low frequency words.

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Chapter 1

Introduction

Brazil poses a number of challenges and opportunities for sociolinguistic research. Its large size and fast growing developing economy led Wilson & Purushothaman (2003) to include it in what they call the BRIC (for Brazil, Russia, India, and China), a group of countries that by 2050 may collectively become richer than today's wealthiest countries. At the same time, Brazil continues to have one of the most unequal distributions of wealth in the world (Central Intelligence Agency, 2008). It seems likely that the large disparity between the highest and lowest socioeconomic classes, along with the social changes brought about by rapid economic growth, would have an effect on how social variables like class interact with language. Nonetheless, few sociolinguistic studies in Brazil have dealt directly with socioeconomic class.

The purpose of this dissertation is to examine the effect of social class, age, and sex on the diphthongization of back vowels before word final /S/ in Rio de Janeiro (eg. *mas* [maiʃ] "but"). Although this case of diphthongization has been previous noted (Giangola, 2001; Head, 1965), no studies have examined it using acoustic measurements, nor have any studies attempted to relate it to social factors.

The diphthongization in question results in the potential merger of words like *mas* "but" and *mais* "more." Some speakers in Rio de Janeiro claim that such words are pronounced identically, while others claim that they make a distinction. However, it has never been determined acoustically whether or not a merger has indeed occurred, and for which speakers. Thus both the (historically) monophthongal and diphthongal vowels will be analyzed to determine whether or not a merger has

occurred for a sample of 36 speakers from Rio de Janeiro. This data will also be correlated with speakers' attitudes toward and perceptions of the linguistic variables, including whether they claim to make a distinction between the two forms in their own speech. This data will be used to determine whether this is a case of a near-merger, in which speakers produce a distinction that they are unable to perceive. Near-mergers are a theoretically interesting phenomenon within linguistics because they challenge many notions like the discreteness of phoneme boundaries and the symmetry of production and perception (Labov et al., 1991).

Much attention has been given to diphthongization as it relates to vowel shifting, particularly chain shifts. In the case of rising long vowels, for example, diphthongization is frequently the result when high vowels reach a maximum height, as when Old English /iː/ and /uː/ became modern English /ai/ and /au/, presumably by first developing glides, then lowering the nuclei (Labov, 1994). However, diphthongization is also frequently a conditioned change, forming only in a specific phonetic environment. Despite Labov's (1994) claim that this is the most common type of diphthongization, is has received less attention in sociolinguistics. Most of the diphthongization in Portuguese, both historically and synchronically, is the result of either conditioned changes, such as glide formation before palatalized consonants (eg. *noite* "night", resulting from the palatalization of [k] in Latin *noctis*), or the vocalization or loss of segments, as in *lua* "moon" (cf. Latin *luna*). This dissertation will focus on the former type of diphthongization, and it will be shown that the phonological environments that favored diphthongization historically in the language are the same ones favoring diphthongization today in certain varieties of Portuguese.

The focus of this dissertation will be off-glides in the direction of [i], which is the most common type found in Portuguese. Historically, this type of diphthongization has affected all varieties of Portuguese, as can be seen when comparing standard Por-

Portuguese	Spanish Cognate	Latin Cognate	Meaning
baixo	bajo	basis	"low"
coisa	cosa	causa	"thing"
depois	después	de post	"after"
dois	dos	duos	"two"
leite	leche	lactis	"milk"
muito	mucho	multus	"a lot"
noite	noche	noctis	"night"
oito	ocho	octo	"eight"
peito	pecho	pectus	"chest"

Table 1.1 : Examples of Portuguese words with off-glides and their cognates in Spanish and Latin.

tuguese to related languages. Table 1.1 shows some examples of words in Portuguese that have off-glides diphthongs while their cognates in Spanish and Latin are either monophthongs or have a different type of glide.

Many of these, (like *oito*) were accompanied by the palatalization and subsequent vocalization of Latin "c" in "ct" clusters (eg. *octo*) (Williams, 1962). A similar change occurred in the "lt" cluster of Latin *multus* to produce Portuguese *muito* (Maia, 1986). The diphthong in *baixo* /bajʃu/ occurs in a similar environment, in this case an alveopalatal consonant.

The "oi" in *coisa* and *dois* alternated with "ou" in the older forms *cousa* and *dous* (Nascentes, 1966). Whereas these ultimately became monophthongs in Spanish, in Portuguese the front glides were eventually favored over the back glides. (The back glides are still found in Galician, a language closely related to Portuguese spoken in northwestern Spain, in the forms *cousa* and *dous*.)

At least two diphthongized variants have been noted in certain varieties of Portuguese, as noted in Head (1965). In Rio de Janeiro, vowels before word final /s/ are diphthongal (eg. *mas* [maiʃ] "but"), and in Lisbon, /e/ is diphthongal before the (alveo-) palatal consonants /ʃ/, /ʒ/, /ʎ/, /ɲ/ (eg. *fecho* [fɐjʃu] "I close"). The first of these will be examined in more detail in this study.

A question raised by both the diachronic and synchronic examples is why diphthongization appears to be favored by palatal, post-alveolar, and alveolar environments. The answer that will be argued is that the articulatory gestures made in these environments favor upgliding, while the articulatory gestures in other environments either disfavor upgliding or favor another type of diphthongization. However, it is important to note that not all of the data can be explained in this way. In addition to the diphthongization of [a] to [ai], there are also cases of the monophthongization of [ai] to [a]. In all of the data collected for this study, pre-palatoalveolar /ai/ is categorically pronounced [a] in open syllables, as in *baixo* [baʃu] "low." Nascentes (1953) claims that this pronunciation is a characteristic of Rio de Janeiro, as well as Southern Portugal and Goa. He also notes that the same monophthongization occurs in the words *caiba* [kaiba] ∼ [kaba] "fit (present subjunctive)" and *saiba* [saiba] ∼ [saba] "know (present subjunctive)", as well as in proper names like *Adelaide* [-aiʤi] ∼ [-aʤi]. Such alterations may be the beginnings of a gradual reduction in the contrast between /a/ and /ai/ in Rio de Janeiro, with [a] occurring more often in open syllables like *caixa* and *caiba*, and [ai] occurring more often in closed syllables like *mas* and *mais*. The contrast does not appear to be weakened word-finally, however, as in *vai* [vai] "go (present indicative)" and *vá* [va] "go (present subjunctive)."

i						u
	e				o	
		ɛ		ɔ		
			a			

MONOPHTHONGS

iu						ui uu̯
	ei eu				oi (ou)	
		ɛi ɛu		ɔi ɔu		
			ai au			

DIPHTHONGS

Table 1.2 : Vowel inventory of Portuguese, as spoken in Rio de Janeiro, showing monophthongal and diphthongal stressed oral vowels.

1.1 Phonology of Rio de Janeiro

Portuguese has a seven-vowel system of monophthongs, as shown in Table 1.2 (left side). In addition, all seven of the monophthongs have diphthongal counterparts. The inventory in Table 1.2 (right side) is for Rio de Janeiro; those in parentheses exist in other varieties, but are not typical of Rio. Some of these diphthongs are limited in their distribution: /ɛi/ and /ɔi/, for example, are mainly found in plural forms such as *pincéis* "pencils" and *faróis* "headlights." In Rio, the vocalization of word final /l/ results in more diphthongs than other varieties. Examples include *mel* [mɛu] "honey" (cf. *meu* [meu] "my"), *sul* [suu̯] "south", and *sol* [sɔu] "sun." The /ɔu/ and /uu̯/ diphthongs occur exclusively as a result of this vocalization; thus they do not occur in varieties that do not vocalize /l/ (as in most of Portugal). Other varieties, particularly in Portugal, have /ou/, but this vowel is generally monophthongal in Rio, eg. *sou* [so] "I am." A contrast is made in Rio between [iu̯], as in *mil* "thousand" and [i.u] as in *rio* "river," though other varieties, such as São Paulo, have [iu̯] for both. Diphthongization of vowels before word final /S/ may result in even more diphthongs than the ones given in Table 1.2; this is discussed further in Chapter 5

Regarding /S/, the archiphoneme is used throughout this dissertation for several reasons. First, the voicing distinction is not maintained word finally, thus *trás*

"behind" and *traz* "bring" are homophonous (both [traiʃ] in Rio). Second, the pronunciation of word final /S/ varies by region: Rio and Lisbon both have [ʃ], but many other varieties in both Brazil and Portugal have [s]. In connected speech, /S/ also assimilates the following sound: in Rio, it becomes [z] before vowel (eg. *mas a* [maiza] "but the"), [ʒ] before voiced consonants (eg. *mas não* [maiʒnãu] "but no"), [s] before another [s] (eg. *mas só* [maissɔ] "but only") and [ʃ] elsewhere.

1.2 Chapter Layout

The chapters of this dissertation are arranged as follows. Chapter 1 provides an introduction to diphthongization and shows why it is an interesting topic to study, and why Portuguese is well suited for this purpose. Chapter 2 provides background information on Brazil and specifically on Rio de Janeiro. It also reviews other relevant sociolinguistic and phonetic studies that have been conducted in Brazil. Chapter 3 discusses the methodology of the study. This is important because analyzing diphthongs is not as straightforward as analyzing vowels without regard to their glides. Chapter 4 provides a detailed phonetic analysis of one speaker. The purpose of this chapter is to show how the following phonetic environment affects glide formation in vowels. Chapter 5 focuses on one of the environments that is shown to favor diphthongization in Chapter 4, namely that of pre word-final /S/, for a larger sample of 36 speakers. This is an attempt to reconcile the advantages and disadvantages of the typical methodology of phonetic studies with that used in sociolinguistic studies. Whereas phonetic studies tend to analyze many more tokens than sociolinguistic studies, they do not include enough speakers to provide any information on interspeaker variation. Sociolinguistic studies are specifically designed to show this variation, but due to the larger number of speakers, it is not possible to analyze the data in as much detail. Thus Chapter 4 is intended to show the phonetic aspects of diphthongization,

while Chapter 5 is intended to show inter-speaker variation and its relation to social factors, namely age, sex, and socioeconomic class. Chapter 6 addresses the issue of whether the minimal pairs *mas/mais* and *paz/pais* are merged in production and perception. It also examines the role of lexical frequency in the sound changes under investigation. Finally, Chapter 7 provides some conclusions and assesses the overall importance of the study.

Chapter 2

Background on Brazil and Rio de Janeiro

Sociolinguistic studies require not only a good understanding of the language being investigated, but also of the society in which the language is spoken. This chapter, therefore, provides relevant background data on Brazilian society, and Rio de Janeiro in particular, which will help inform the analysis of the social aspects of my data. It will also provide a review of the previous sociolinguistic research done in Brazil (as well as one neighboring country), and show how it is relevant to this study.

2.1 Introduction to Brazilian Society

Brazil is the fifth largest country in the world, both in terms of land area and population. It is also one of the largest predominately monolingual countries in the world, with Portuguese spoken by over 99% of the population (Hudson, 1998). Although many indigenous languages are spoken in Brazil, their speakers make up less than one tenth of a percent of the population (Gordon, 2005). There are also numerous immigrant groups in Brazil, particularly German, Italian, and Japanese, although the total immigrant population of Brazil is only 0.34% (as compared to nearly 13% in the U.S.) (United Nations, 2005). Like most other countries that have become industrialized only in the last 50-60 years, Brazil is neither among the wealthiest nor the poorest of the world's nations. With a per capita gross domestic product (GDP) of $9,700 in 2007, only slightly less than the world average of $10,000 (Central Intelligence Agency, 2008), Brazil is firmly established as a middle-income country. What is striking about Brazil is its unequal distribution of income, as well as widely divergent

standards of living.

According to the Gini Index, a measure of income distribution, Brazil ranks 122 out of 133 countries ranked, making it one of the most unequal in the world (Central Intelligence Agency, 2008). By the same index, Brazil is the most unequal of all countries with a population of over 50 million. This inequality is particularly visible in Rio de Janeiro, where it is common to see squatter communities, known as favelas, in very close proximity to luxury condominiums.

The (socio-)linguistic consequences of such widespread inequality have yet to be fully explored. Hudson (1998) claims that despite such inequality, class solidarity is not strong in Brazil. Instead of developing strong intra-class ties, people in lower classes tend to develop strong relationships with those who have more power and prestige. Such ties can be advantageous not only for the lower class, who may use them as a form of upward mobility, but also to the more prestigious classes, who often depend on the lower classes for domestic employment and childcare. Thus the lack of intra-class solidarity may reflect a lack of autonomy on the part of both lower and upper classes.

Nonetheless, class-based prejudice is very strong in Brazil; according to some, it is a more powerful source of prejudice than racism (see, for example, Wagley, 1963; Winant, 1994). This is particularly apparent in attitudes toward the favelas, where most of the urban lower class in Brazil lives, as explained further in the section Favelas. Consequently, the speech of the lower class in Brazil is highly stigmatized. Thus while class is clearly an important factor in linguistic variation, it is not clear whether the resulting differences are due to class solidarity, or rather social isolation and lack of access to the more prestigious varieties.

2.2 Introduction to Rio de Janeiro

Rio de Janeiro is the second largest city in Brazil, behind São Paulo, with a population of over 6 million, and a metropolitan population of over 11 million (Instituto Brasileiro de Geografia e Estatística, 2008). The metropolitan area includes the city of Rio itself, plus fifteen surrounding municipalities, the largest of which are São Gonçalo, Nova Iguaçu, Duque de Caxias, and Niterói.

The speech of Rio de Janeiro is often considered the most prestigious in Brazil (Leite & Callou, 2002), a idea that is not surprising given Rio's importance as a cultural and former political center in Brazil. It was the national capital until 1960, when it was moved to Brasília; it continues to serve at the headquarters for most of Brazil's largest media outlets, including Globo, by far Brazil's largest television network (and fourth largest in the world [Kraul 2008]). Due to its prestige, the educated pronunciation of Rio de Janeiro is usually used as the national standard, and is the pronunciation most often used in foreign language dictionaries (Araújo & Grundy, 2008; Taylor, 1970; Whitlam et al., 2001).

2.3 Social Class and Social Mobility

Numerous ways of categorizing socioeconomic classes in Brazil have been proposed. In Brazil, the classes are commonly referred by the letters A, B, C, D, and E, with A being the upper class. In come cases, these may be further divided as A1, A2, etc. The Brazilian Association of Research Companies (Associação Brasileira de Empresas de Pesquisa *or* ABEP), provides an estimation of socioeconomic class based on education and possession of goods, such as automobiles and household appliances, house size (measured in number of bathrooms), and number of hired domestic workers. The results for both Brazil in general and for the Rio de Janeiro metropolitan area are

Class	Percentage of Brazil	Percentage of Rio de Janeiro	Average monthly salary (US$)
A1	0.9%	0.6%	$4042
A2	4.1%	3.4%	$2726
B1	8.9%	8.3%	$1445
B2	15.7%	14.3%	$836
C1	20.7%	23.1%	$496
C2	21.8%	24.6%	$302
D	25.4%	24.8%	$201
E	2.6%	1.2%	$115

Table 2.1 : Social classes in Brazil and Rio de Janeiro, according to Associação Brasileira de Empresas de Pesquisa (2008).

given in Table 2.1, along with the average monthly household salary[1] of each class.

Under this classification system, Rio appears to be close to the national averages in terms of distribution of social classes. The only major difference is a larger percentage of the middle classes (C1 and C2) at the expense of the upper and lower classes. However, this system is predominately used by companies for marketing purposes, such as estimating the potential size of consumer markets; thus it is heavily based on the consumption of goods. There is no evidence that such a scheme has any social reality for the people themselves.

Economists and sociologists tend to use classification systems based on profession type. Ribeiro & Scalon (2003) devised a scheme based on the widely used EGP class scheme, so called because of the initials of its creators, Erickson, Goldthorpe, &

[1]The exchange rate used is 1 US Dollar = 2.408 Brazilian Reais, the average value in 1995, the year the data were collected.

Class	Description	Percentage of Brazil (Destination)	Percentage of Brazil (Origin)
I+II	Professionals, administrators, and managers	10.4%	4.7%
III	Non-manual routine workers	12.3%	5.9%
Iva+b	Petite bourgeoisie	10.6%	7.6%
Ivc1	Rural employers	1.2%	2.7%
V+VI	Skilled manual workers	21.1%	14.6%
VIIa	Non-skilled manual workers	24.2%	12.4%
VIIb	Rural workers	20.2%	51.9%

Table 2.2 : Social classes in Brazil according to Ribeiro & Scalon (2003).

Portocarrero (1979). They used data from the National Sample Surveys of Households (Pesquisa Nacional por Amostra de Domicílios *or* PNAD), a part of the Brazilian census, to classify Brazilian occupations according to the EGP scheme. One of the advantages of this class system it that is widely used and allows for comparison with other countries. A potential drawback is that it is based on Western European societies, although Ribeiro & Scalon have modified it to be better suited to Brazilian society. In particular, they introduced a rural/urban distinction into the scheme, since this seems to be particularly relevant in Brazil. They used this scheme to estimate the amount of social mobility in Brazil by comparing one's social class ("destination") with that of one's father's class ("origin"). The resulting system is shown in Table 2.2, along with "destination" and "origin" percentages for 1996.[2] Roman numerals are based on the EGP scheme.

[2]Data are for Brazil in general; data for individual metropolitan areas are not available.

What is most apparent in this data is the shrinking of the rural classes (Ivc1 and VIIb) and the expansion of the urban classes (all others). This is not surprising, given Brazil's recent transition from a predominately rural society to a predominately urban one. The vast majority of the rural workers become non-skilled and skilled manual urban workers. In terms of class mobility, Brazil is within the range of other modern industrialized countries. The movement toward the upper classes reflects an increasing number of positions available due to industrialization and urbanization. Thus, as in most recently industrialized societies, class mobility in Brazil is due more to structural changes in the economy than to the openness of the classes themselves (Ribeiro & Scalon, 2003). This analysis is consistent with the large and growing inequality of wealth in Brazil; while there are an increasingly large number of opportunities for obtaining higher socioeconomic status in Brazil, there is little exchange of membership among upper and lower classes.

2.4 Favelas

No discussion of social class in Brazil would be complete without mention of the large squatter communities known as favelas, generally representing the lowest socioeconomic classes in Brazil. In Rio de Janeiro, there are over 700 favelas, with a population of 1.65 million people (Perlman, 2005). According to the Brazilian census (Instituto Brasileiro de Geografia e Estatística, 2008), the proportion of Rio's population that lives in favelas has steadily risen with each successive decade, from 7% in the 1950s to almost 19% in 2000s. In the 1990s, Rio's overall population increased by 7.6%, while the population of its favelas increased by 40.5%. In "The Myth of Marginality" Perlman (1976) argues against certain widely held beliefs about favelas and their residents in Brazilian society. Many of these beliefs continue to the present day, and often came up in my interviews with middle class Brazilians. One

of the most widespread is the view that favelas are like a parasite on the city, ruining its natural beauty, and causing a drain on the economy by demanding public services while contributing little or nothing to the society. Stereotypes about the residents themselves claim that they are usually migrants from the poorest rural areas in Brazil, thus representing the most destitute members of society. The fact that the original migrants were usually squatters, illegally occupying the land on which they live, leads to the view that favela residents do not respect the laws and values of society.

Perlman's 1976 sample of 600 residents of three favelas in Rio showed that favela residents are not a homogeneous group. While it is true that a large portion of residents are unemployed (41%), the majority of the residents do work, generally in unskilled jobs. Although most of the residents are migrants, only 23% come from the Brazilian countryside (*roça*). Over half of the migrants come from medium-sized towns (*sedes municipais*) or from other large cities. In terms of education, Perlman and others have shown that the migrants themselves do not come from the lowest socioeconomic classes in Brazil. Indeed, as Morse (1970) shows, migrants to large cities in Brazil are above national averages in terms of education, skills, and acquaintance with the urban lifestyle. Germani (1965) found no correlation between the degree of rural poverty and the tendency to migrate to large urban centers. Baer (1964) found that people do not migrate any more from economically depressed areas of Brazil (such as the Northeast) than they do from more prosperous areas (such as the South). In most cases, the possibility of making a long journey to another city and finding work there is not available to those living in extreme poverty.

The actual reasons for urban migration are not always entirely economic. Many complex factors may be involved, including larger variety of job types in the city, desire for a more socially active lifestyle, need for better medical treatment, or desire to find a mate. Although many middle class city dwellers view the favela lifestyle as

marginal and even subhuman, for the migrants themselves, life in the favelas almost invariably represents an increase in quality of life. As urban residents, people in the favelas have more job opportunities, and greater access to basic sanitation, education, and health care.

Rural to urban migrants provide many of the same functions in Brazilian cities as immigrants do in the United States and other of the so-called industrialized nations. They are a vital source of cheap labor, and thus are an integral part of society; yet they are not accepted as such by the middle and upper classes. Hence many researchers have preferred the more accurate term “stigmatized” to “marginalized,” since “marginalized” implies that they live on the fringes of society. Thus the idea of “marginality” reflects more a desire on the part of the mainstream members of society than a reality for the migrants or immigrants themselves.

Perlman (1976) argues that rather than being marginal members of society, favela residents are well-integrated into the urban lifestyle of Rio de Janeiro. Contrary to the popular opinion that favela residents are lazy and prefer to seek out a life of crime rather than improve their skills through education and job training, most residents have a strong work ethic, and have aspirations to improve their lives and provide a better life for their children. My own work in one of Rio’s favelas confirms these findings, and even suggests a generational gap in the resident’s ambitions and attitudes toward society. The ambitions of the older generation in my sample tended to be limited to making improvements to their houses and having enough money to provide good food for their children. Most of them have limited knowledge of issues outside of their immediate surroundings. They had great difficulty, for instance, in answering questions that required even stereotypical knowledge of what life was like in other Brazilian cities or in other countries. The younger generation was invariably more worldly in their knowledge; they were able to talk about issues such as

national politics and global warming. Most were actively seeking to improve their lives through education, though they were limited to public schools and free courses by their financial situation.

More recent work shows that life in Rio's favelas has changed considerably in the last few decades, both for better and worse. The government's policy of eradicating favelas came to an end as Brazil began a transition to toward democracy in the late 1970s (Arias, 2006). The adoption of Brazil's new constitution in 1988 gave favela residents the same rights as all other citizens. The current Brazilian president, Luiz Inácio "Lula" da Silva, grew up in a favela in the Northeast of Brazil, thus becoming Brazil's first president of lower-class origins. He has pledged full land regularization for all squatters (Perlman, 2005). Thus it is no longer possible to define favelas as squatter settlements. Furthermore, most houses in the favelas now have basic amenities like water, sewage, and electricity. In my interviews with favelas residents, they noted that many houses in the favelas now have telephones, internet, and cable television, though the later two are not necessarily arranged legally. An "internal" real estate market has developed within the favelas, and prices in favelas located in Rio's most desirable areas (such as Zona Sul "South Zone") often rival those of regular neighborhoods.

What has not changed, however, is the stigma attached to the favelas by non-favela inhabitants. In fact, it is not uncommon to refer to rundown apartment complexes and former housing projects as favelas, even though these are not, nor ever were, squatter settlements. The word "favela" today seems to have become not just a term for illegal or formerly illegal squatter settlements but a derogatory term for poor communities in general. In my own interviews, none of the favela residents themselves used the term *favela*, instead preferring *comunidade* "community" or occasionally *morro* "hill" to refer the place where they live.

Perhaps the single greatest change to Rio's favelas in recent decades has been the increase in crime and violence due to the expansion of drug trafficking in the favelas. Although the drugs are grown and processed in Andean countries like Peru, Bolivia, and Colombia (WGBH Educational Foundation, 2008), Rio has become a major hub of the retail and wholesale drug trade. Rio's favelas, which are usually located on steep hillsides, provide ideal places to hide drugs and weapons. Inside the favelas, the trade employs many people in a hierarchy of positions, including managers, dealers, soldiers, couriers, and look-outs. Children as young as ten or eleven may enter into the business (Arias, 2006). Although most favela residents themselves are not directly active in the drug trade, the increase in violence, particularly between the police and the drug gangs, has led to a growing sense of insecurity and diminished sense of unity within the favelas. Residents often fear the police more than the gang leaders, although neither group is well respected or trusted by most residents (Perlman, 2005).

The linguistic situation of Rio's favelas (as well as those of other major cities in Brazil), has not been fully explored. Given the fact that favela residents are integrated into the economy of the city, albeit in the form of unskilled labor, one cannot assume that favelas represent a rural enclave in an urban center. Thus, we would not expect to find that favelas residents who are born in Rio would retain many (or any) rural features in their speech. Indeed, studies such as Bortoni-Ricardo's (1985) study in Brasília suggests that this is true, as explained in Section 2.7.

However, given the high stigma attached to favelas, if there are linguistic variables associated with them, they are likely to be highly stigmatized. This stigma, combined with the increasing lack of unity in the favelas as a result of the drug trade, could force most residents to orient their speech patterns toward those of the middle and upper classes, rather than use their speech as a marker of identity within the favela. None of these hypotheses, however, has been tested empirically.

2.5 Race

Given the fact that Brazil is a very racially diverse country, and that race has been widely discussed in sociolinguistic studies in other parts of the world (particularly in the U.S.), it is important to make some mention of it here. As in most of the New World, African slave labor was a very important part of Brazilian history. Thomas (1997) estimates that Brazil was the final destination of 35% of all slaves from Africa, far larger than any other country in the New World (compare this to only 4% for the former British colonies, including what became the U.S.) This combined with the fact that slaves from the same or similar linguistic and cultural backgrounds were less likely to be split up upon arrival in Brazil has led a much stronger presence of African cultural heritage in Brazil than in the U.S. (Van den Berghe, 1967). This can be seen in the prevalence of African-based religions in Brazil, such as Umbanda and Candomblé, in Brazilian cuisine, music, and even dress (eg. the practice of wearing white on Fridays to pay homage to the orixás, or Yoruba deities.) Given Brazil's strong African cultural heritage, one might expect racial differences in language to be even larger in Brazil than they are in the U.S. However, a key difference is that while race is defined largely dichotomously in the U.S., it is much more fluid in Brazil. Numerous categories of race are currently used in Brazil, going well beyond just "black," white," and even "mulatto" or "mixed." In addition, numerous classification systems are simultaneously in use. Aside from categories for Asians and indigenous people, the Brazilian census defines three races: *branco* (white), *pardo* (brown), and *preto* (black). In addition, there are many other terms used in popular discourse, such as *moreno* (brown), *moreno claro* (light brown), *negro* (black), and *claro* (light). Thus many people who self-identify as black in the U.S. would not be considered as such in Brazil. Generally, only those with the darkest skin would be considered black in Brazil. In more recent years, black-movement activists in Brazil have encouraged the

adoption of a dichotomous "white/black" distinction. They feel that the relatively small portion of the population who self-identify as "black" has led to increased marginalization and the belief that being "brown" is better than "black." So far, though, this new system has not been widely adopted in all circumstances. The resulting situation is one in which the entire concept of race is very fluid; people may define their own race as well as the race of others differently depending on the situation (Telles, 2004). It is also interesting to note that despite the strong African cultural heritage in Brazil, there is no term in Brazil paralleling that of "African-American," as used in the U.S. Indeed, the term *cor* "color" is more commonly used than *raça* "race" (Telles, 2004), which is actually more accurate given the continuous way that race is conceptualized in Brazil. The resulting fluidity is reflected not just in the way race is conceptualized, but in cultural practices as well. Prandi (1995) noted that in some parts of Southern Brazil, there are more white followers of the African religion Umbanda than blacks and browns. Even Candomblé, which is often considered to be more authentically African than Umbanda, has numerous white and brown followers throughout Brazil. In Rio de Janeiro alone, there are estimated to be about 165,000 white followers of African-based religions, about a quarter of all followers of African religions in Rio.

2.6 Diphthongization of Back Vowels

In this study, I will deal specifically with the diphthongization of back vowels before word final /s/, eg. *mas* [maiʃ] "but" in Rio de Janeiro. The earliest know reference to this variation in the literature is in Rossi's (1945) grammar of Brazilian Portuguese, giving both *mas* "but" and *paz* "peace" as examples. This suggest that the diphthongal variant has existed for many generations, though he does not mention which varieties of Brazilian Portuguese use it.

The history of diphthongal *mas* itself is much older, however. Both *mas* and *mais* derive from the Latin *magis* "more." *Mais* was used in the sense of "but" as early as 1204, and continued to be used in writing through the fourteenth century (Machado, 1967). In modern Galician, a language whose history is closely tied to that of Portuguese, *mais* survives as both "but" and "more." This suggests that the history of *mas* may be different from other words that have diphthongal /a/, such as *paz*. In fact, some speakers of Portuguese outside of Rio de Janeiro claim that *mas* does not sound natural with a monophthongal vowel, even though other words like *paz* do. It may be that the diphthongal variant of *mas* was never lost in the language, and continues to exist even in varieties that do not otherwise diphthongize /a/ before word final /S/.

Although no systematic study has been done on the subject of diphthongization in this environment, Giangola (2001) provides a relatively detailed description of it. He notes that it is a characteristic of Rio de Janeiro, Baía (Salvador), and Northeastern dialects. It can occur with any vowel except /i/, though it is most noticeable before back vowels, with glides in the direction of [i]. In some cases, it can occur with nasalized vowels, as in *maçãs* [masɐ̃iʃ] "apples." My own observations indicate that this is indeed a common pronunciation in Rio. Giangola claims that attitudes toward this diphthongization vary. Those who do not have this feature in their speech usually consider it to be incorrect, often citing the spelling as evidence. It is absent in the speech of many announcers, but very common in soap operas (*novelas*), even by actors who do not have the feature in their own speech. Some speakers who use it may themselves consider it as incorrect, while at the same time, the omission of the glide might be considered pretentious or affected. Others may simply view it as a regional variation, with no associated stigma. Giangola's observations, however, are informal, and are not backed up by actual sociolinguistic research. He also makes no

mention of whether this diphthongization results in a merger with words like *mais* [maiʃ] "more." Thus many aspects of the phenomenon await empirical investigation: its phonetic detail, its relationship to social factors, and a detailed account of speaker attitudes.

2.7 Previous Sociolinguistic Studies in Brazil

One of the most thorough and widely cited sociolinguistic works conducted in Brazil is Bortoni-Ricardo's (1985) study of the rural to urban migrants in Brazilândia, a satellite community of Brasília. She selected four linguistic variables to examine, all of which are typical of rural dialects of Brazil: the vocalization of /ʎ/ (eg. *folha* [foʎa] ∼ [foja] "leaf"), reduction of final rising diphthongs (eg. *armário* [armarju] ∼ [armaru] "cupboard"), and subject-verb agreement in the first and third person plural (*nós queríamos* ∼ *nós queria* "we wanted"; *eles queriam* ∼ *eles queria* "they wanted"). The study focused on the following social factors: sex, age, amount of media exposure, and work type (skilled vs. unskilled). Of these, age and sex frequently showed up as significant factors for the four linguistic variables she examined. Amount of media exposure was significant for one variable (the vocalization of /ʎ/), while work type showed only a minor effect, if any.

The vast majority of Bortoni-Ricardo's participants were rural migrants who had come to Brazilândia at various stages of their lives. Her study showed that time spent in the urban environment lead to a reduction of the (usually stigmatized) rural features of their speech. Although she mentions that the process of urbanization results in the transformation of rural dialects into non-standard urban varieties, the study does not investigate whether successive generations of lower-class speakers retain any of the non-standard variables in their speech. In the introduction, she raises the question "to what extent is there an ideology of prestige operating among the so-called

marginal population?" (Bortoni-Ricardo, 1985). However, she ultimately leaves the question of whether the maintenance of non-standard forms is used as a sign of group identity to be answered by further research.

Bisol (1989) looked at the phenomenon of vowel harmony, by which the unstressed (pretonic) vowels *e* and *o* variably become *i* and *u* respectively in the presence of a high vowel in the following syllable, in the southern Brazilian state of Rio Grande do Sul. She found that speakers in the state capital (Porto Alegre) showed a higher degree of vowel harmony than speakers near the border with Uruguay and speakers in two different rural regions, most of whom were decedents of German and Italian immigrants. However, by conflating "region" with "ethnic group," it is not clear whether the results show the presence of ethnic variation in Rio Grande do Sul, or just regional variation, and in particular an urban/rural distinction.

Callou et al. (1995) looked at a similar variation in the use of pretonic vowels in Rio de Janeiro. In this case, some words have pretonic vowels that alternate between [e, o] and [ɛ, ɔ], which the authors refer to as "lowering," while other words have alternation [e, o] ∼ [i, u], referred to as "raising." In rare cases, a single word may even have all three variants, such as *comer* "to eat" [koˈmer] ∼ [kuˈmer] ∼ [kɔˈmer]. Although no significant social differences in the use of the lowered variant were found, the raised variant showed a curvilinear pattern with respect to age, with the youngest group (25-35 years) and the oldest group (over 50 years) having the most amount of raising. A similar pattern has been found in American English with variables such as negative concord and "-in"/"-ing," and usually suggest a stable sociolinguistic variable, with middle aged groups avoiding the use of the stigmatized variant (Labov, 2001). In addition, they found a difference by region of the city, with the North Zone and Suburban Zone showing higher use of the raised variant than the South Zone. However, since the South Zone is where Rio's most prestigious neighborhoods are

located (such as Copacabana, Ipanema, and Leblon), this probably reflects a class difference more than a regional difference within the city.

Callou (1987) is a similar study looking at the same social/geographical variables in Rio de Janeiro (sex, age, and region of the city) for post-vocalic /r/. In this case, there appears to be a change in progress, with the standard velar pronunciation [x] becoming [h] or Ø, as in *falar* [-ax] ∼ [-ah] ∼ [-a] "to speak." Both the [h] and the zero variant show age grading, with young females in the lead. Area of residents does not appear to have any effect in this case.

Callou & Marques (1975) examine post-vocalic /s/, also in Rio de Janeiro. Generally the pronunciation of this variable assimilates to the following phonetic environment, with [z] occurring most often before vowels, [ʒ] before voiced consonants, and [ʃ] elsewhere. Similar to post-vocalic /r/, the variants [h] and Ø are also used, but they as not as common as in the case of /r/. They compared the use of these variants to the informants' educational levels. Those with the highest level of education showed almost no variation from the standard pronunciation (that is, the use the variants were almost entirely predicted by the phonetic environment), while those with the lowest level of education showed more frequent use of the aspirated and deleted variants. Interestingly, those in the intermediate educational level showed the largest amount of variability, with variants such as [s] also occurring, as well as complete assimilation with the following consonant, as in *poste* [pɔʃʧi] ∼ [pɔʃ^{i}] "pole," but without any particular variant or type of variation predominating. Some variants were also found to be more frequently used in certain regions of the metropolitan area, particularly among females.

This study is particular relevant since it deals with the same phonetic environment that is the focus of Chapter 5, that of pre word-final /s/. Although they did not analyze the occurrence of diphthongization in this environment, the phonetic tran-

scriptions of their data published with their study allows for some observations to be made. In the case of back vowels before word final /s/, the glide [i] is used categorically in their transcriptions, as in *arroz* [aˈɣoⁱʃ] "rice," while it is almost categorically absent in word medial syllable final /s/, as in *casca* [ˈkaʃka] "shell." The only exception was one instance of *castiçal* [kaiʃʧiˈsau] "candlestick." This later variant, that of diphthongization in word-medial unstressed syllables (but apparently not in stressed syllables), will be looked at further in Chapter 5.

Battisti et al. (2007) looked at the variable palatalization of alveolar stops before the high front vowel (eg. *tipo* "type" [tipu]   [ʧipu]) in Antônio Prado, a small town in the state of Rio Grande do Sul. The palatalization of alveolar stops is a widespread feature of Brazilian Portuguese (in fact, it is categorical in Rio de Janeiro), but in Antônio Prado, its occurrence is less frequent (29% in Battisti et al.'s study). They found that the occurrence of the palatalized variant correlated with both age and location in either the urban or rural part of the municipal area. The also found an effect of education level in the urban area. In terms of prestige, the study shows an interesting interplay between local prestige (reflected in the retaining of alveolar stops) and national prestige (reflected in palatalization). Rather than finding an age-graded change in which successive generations use more of the national prestige form, they found that among the youngest age group (15 to 30), the frequency of palatalization seems to have leveled off at around 42%, not significantly different from the next oldest age group (31 to 50). Questions that are not addressed in the study are whether the use of alveolar stops has become a marker of local identity among those speakers who use them variably, and what are the speakers' attitudes toward the palatalized variants.

Naro & Scherre (2000) looked at the rate of subject-verb concord among both literate and illiterate speakers from Rio de Janeiro. Most of the study focused on

internal linguistic factors such as the salience of the verb form (eg. irregular verb forms are usually more salient that regular forms), and position of the verb in relation to the subject. He did note, however, that literate speakers use more subject verb concord than illiterate speakers, both in the salient and non-salient categories. Such a result would not be surprising to most Brazilians, since the lack of subject-verb concord is highly stigmatized in Brazil (Bortoni-Ricardo, 1985). Although the literate-illiterate distinction is not the same thing as a socio-economic class distinction, it is no doubt related, and could in fact be a factor in determining class.

Guy (1981) looked at variable plural marking on both nouns and verbs in the lower class speech of Rio de Janeiro. The regular plural markers in Portuguese are a final "-s" for nouns (eg. *casa* "house," *casas* "houses") and nasalization of the final vowel for present tense verbs (eg. *come* "[he/she] eats" *comem* "[they] eat"). This variation is related to the more general phonological processes of final "-s" deletion (eg. *menos* ∼ *meno* "less") and denasalization of final nasals (eg. *homem* ∼ *home* "man"). As all of his data were from lower class, illiterate speakers, he did not examine social class as a potential factor.

He found that young adults have more "-s" deletion than teenagers or older adults, and men show more "-s" deletion than women. As the data did not show age grading, Guy concludes that this variable is not a change in progress. The sex difference is a common one in sociolinguistics, with women favoring the more standard form. Similar results were found for variable plural marking. A similar sex difference was also found for the denasalization of final unstressed nasal vowels and variable plural marking on verbs.

Carvalho (1998) investigated the use of Portuguese among Spanish/Portuguese bilinguals in Rivera, an Uruguayan town near the border with Brazil. She looked at two linguistic variables: the vocalization of /ʎ/ (eg. *filha* [fiʎa] ∼ [fija] "daughter")

and the retention of the alveolar stops /t/ and /d/ before /i/, as opposed to palatalization (eg, *tipo* [ʧipu] ∼ [tipu]). She found that the variants that are typical of urban Brazilian Portuguese are thought to be prestigious, while the local variants are stigmatized. She views this as an instance of dialect diffusion, as local variants were probably once categorical in the region, while the new variants have been imported from prestigious cities in Brazil (particularly Rio) via the media[3] and other sources. In the case of /ʎ/, the local variant is highly stigmatized in both Brazilian Portuguese and Uruguayan Portuguese, and locals are well aware of the difference between what they call "border" features of their speech and "Brazilian" features. Several social factors were found to be important in the use of the /ʎ/ variable, including (in order of Varbrul factor rank) style, socioeconomic class, gender, and age. The fact that social stratification is accompanied by stylistic stratification is typical of stigmatized variants in sociolinguistics.

Although the retention of alveolar stops before /i/ is not as stigmatized as /ʎ/, the palatalized forms are quite prestigious, and have become a stereotype in the region for people wanting to sound "Brazilian." Age was the most important social factor for this variable, followed by social class and gender. Overall, the palatalized forms are preferred increasingly by younger generations, the middle class, and females. Carvalho concludes that both palatalization and the use of /ʎ/ are examples of dialect diffusion, by which some groups (particular young middle class females) are orienting their speech more toward national prestige forms and less toward the local dialect. What makes this situation unique is that the national prestige appears to have crossed national borders, affecting Portuguese spoken in Uruguay, a predominately Spanish-speaking country.

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[3]Although the role of the media in introducing new linguistic variants has been doubted by many sociolinguists, Carvalho argues that, at least in this case, it appears to be a significant factor.

She also looked at the speakers' choice of Spanish vs. Portuguese, and found that the working class, men, and older generation tend to favor the local variety of Portuguese, especially in informal contexts, while other groups use more Spanish in these contexts, having been influenced by the more prestigious culture of the Spanish-speaking capital, Montevideo. The resulting situation is one in which bilingual speakers seem to be modeling their linguistic behavior on two external norms: on the one hand, Spanish, the national language, and on the other hand, Brazilian Portuguese, the language of a neighboring country, while the local Portuguese variety is usually stigmatized as a "mixed" or "impure" language.

Collischonn (2003) looked at vowel epenthesis (eg. *opção* [op(i)sãu] "option") in six different cities in Southern Brazil. In the largest cities (the "capitals"), the use of epenthesis decreased with the educational level of the informant, though this was not the case for the smaller towns, in which Portuguese-German bilingualism is common. Collischonn concludes that in the smaller towns, epenthesis is used mainly to mark words of Portuguese origin but not German origin, while in the larger cities, it is more phonetically conditioned, varying by the rate of speech.

Da Hora (2006) also looked at the vocalization and deletion of word final /l/, as in *jornal* [-aɫ] ∼ [-au] ∼ [-a] "newspaper", in João Pessoa, the capitol and largest city in the Northeastern Brazilian state of Paraíba. He found that /l/ deletion occurs only in informants with the least amount of education. The velarized form [ɫ] appears to be an older form, occurring predominately in informants over 65 years old.

De Oliveira (1983) looked at variation in liquids in Belo Horizonte, a major city in Southeastern Brazil, in the state of Minas Gerais. Belo Horizonte is a relatively new city, having been planned as a new state capital in the 1890s. Thus, like the national capital Brasília, the entire history of Belo Horizonte is marked by migration from other regions and thus dialect mixing. Interestingly, De Oliveira found seven

variants of postvocalic "r" in his sample, in addition to "r" deletion, although most of the variants occurred rarely. Based on age-grading of the data, he found that retroflex and alveolar trills are being replaced by velar trills and fricatives, or by [h]. In addition, young speakers tend to favor "r"-deletion in some environments, suggesting a change in progress. Social class also turned out to be an important factor. For example, he found that the [ɚ] variant (similar to the postvocalic "r" in American English) is more common among the lower classes. Indeed, this variant is highly stigmatized throughout Brazil (including Rio). Upper middle class informants preferred the velar fricative [x], a variant that is also common in Rio de Janeiro. Young people also showed a strong social stratification in terms of "r" deletion, a situation that is surprising similar to one in American English, namely, that of New York City (see Labov 1966). In terms of sex, he found that men used more taps and have more deletion of "r" than women, but otherwise most of the variants were not correlated with sex.

The other liquid that De Oliveira (1983) examined was /ʎ/. He found that the realization of /ʎ/ as [l], although not common, occurs mostly in lower socioeconomic classes. He claims that [l] is likely a variant that is disappearing from the community. Another variant of /ʎ/, that of [j], is more common, and highly stigmatized throughout Brazil. As in other cases of stigmatized forms, it is favored by lower-class men, while women and the upper classes tend to avoid it. He found no evidence of age-grading for the use of [j] variant.

De Oliveira claims that much of the variation in Belo Horizonte can be explained in terms of the rural/urban distinction, with variants that are associated with rural speech gradually being eliminated from the urban dialect, while those that are associated with other large urban centers (especially Rio) are on the rise. One of the most interesting findings of the study is that "r" deletion appears to be a change in

progress (based on age-grading) led by the lower class; it does not show the curvilinear pattern of social stratification found in many North American and European cities, in which the working class or lower middle class appears to be leading the sound change. De Oliveira attributes this to a difference in the class structure of Brazilian society, namely that the lower class is the largest class, while North America and Europe tend to have a larger working or lower-middle class, with a much smaller lower class. This, in turn, is reflected in which groups tend to dominate in terms of linguistic changes in progress. Also of note is that "r" deletion is a sound change led by men, which is contrary to the finding in other societies that sound changes originating in lower classes tend to be led by women. De Oliveira attributes this to differing roles that women play in society, particularly that women in the lower class in Brazil tend to have less contacts outside the home than men.

2.8 Discussion of Sociolinguistic Research

The rural/urban distinction in speech patterns shows up frequently in sociolinguistic studies in Brazil (Bortoni-Ricardo, 1985; Collischonn, 2003; De Oliveira, 1983). This is not surprising given that Brazil has only recently completed the change from an agrarian society to an industrialized urban one. Few studies, however, have focused on socioeconomic class as a linguistic variable in Brazil, however, the biggest exception being De Oliveira (1983). Some studies have included factors that are related to class, such as education in the cases of Battisti et al. (2007), Collischonn (2003), and Da Hora (2006), literacy in Naro & Scherre (2000), work type (skilled vs unskilled) in Bortoni-Ricardo (1985), and region of the metropolitan area in Callou et al. (1995) and Callou (1987). However, the relationship between class and any one of these variables may not a straightforward one, and none of these authors suggest that any of the variables should be interpreted as class. This is a topic that deserves further

study, not only because it has not been fully explored, but also because much has changed in Brazil since De Oliveira's study. The economy has grown considerably, urbanization rates have increased, and the class system has changed. Based on Ribeiro and Scalon's (2003) data, as shown in Section 2.3, the skilled labor class, which is roughly the equivalent to the working class or lower-middle classes in North America and Europe, is now nearly as large as the lower class. In addition, Rio de Janeiro is different from Belo Horizonte, where De Oliveira did his research. As noted in Section 2.3, the middle class is slightly larger in Rio than in Brazil as a whole (a point also noted by Guy [1981]). Thus, it is likely that the sociolinguistic situation in Rio in terms of social class may be quite different from what research in other areas in Brazil has shown.

Also in striking contrast to sociolinguistic work in the U.S. is that race has never been determined to be an important sociolinguistic variable in Brazil. Although this does not preclude the possibility that future studies may find race to be an important social factor in language variation in Brazil, there is reason to believe that it may not be as important as it is in the U.S. There is no widely recognized "Black Portuguese" in Brazil, and unlike the U.S., the issue has never come up in the media. This is despite the fact that race is an important issue in Brazil, as often reflected in issues of racial inequality and racial discrimination, as well as racial pride. However, given the fluid way in which race is conceptualized in Brazil, as explained in Section 2.5, this situation is not surprising. If race-based differences in speech do exist, they are likely to be as fluid and difficult to define as the concept of race itself is in Brazil.

The sociolinguistic work done in Brazil provides some support of generalizations made about the relationship between language and sex, as summarized in Labov (2001). Guy (1981) and Carvalho (1998) both support the claim that women tend to use standard or prestigious forms more than men, while both Callou & Marques

(1975) and Callou (1987) show women leading in what may be innovative changes from below in Rio de Janeiro.

2.9 Conclusion

In this study, I intend to focus on socioeconomic class, sex, and age as potential social variables, as these have all been found to be important in previous studies. Following studies like Labov (2001), class will be defined as a composite variable, based on occupation, education, and neighborhood. Since the urban/rural distinction and the consequences of urbanization seem to have been well explored in the literature, I will not focus on these topics in this study, instead limiting my participants to people who were born and raised in the metropolitan area of Rio. I am particularly interested in exploring the issue of social class in Rio, given that it has not been studied from a sociolinguistic linguistic perspective. Although race would also be an interesting variable to examine, its complexity deserves a separate study; therefore I will not analyze race as a potential factor at this time. Even if future studies were to show that it is an important factor in language variation, however, the difference would no doubt be minimal in comparison to the importance race plays in linguistic variation in the United States (unlike in the U.S., it is generally not possible in Brazil to identify one's race based on speech alone). This in itself is an important observation, and shows how language variation tends to reflect the way social categories are defined in a given society.

Chapter 3

Methodology

The data for Chapters 4 and 5 were collected under different circumstances and with different equipment. The data for Chapter 4 includes one conversation-style interview, which I conducted in the United States in 2002. The participant lived in Niterói, a suburb of Rio de Janeiro, and was visiting the U.S. at the time of the interview. The interview was recorded with a Sony Digital Audio Recorder (PCM-M1) using a Sony condenser microphone (ECM-MS957). It was digitized on a TASCAM DA-20 MK II Digital Audio Tape Deck using a USB Pre-amp at a sampling rate of 48 kHz.

The data for Chapter 5 consists of 36 conversation-style interviews recorded in Rio de Janeiro between 2006 and 2008. They were recorded on an M-Audio Microtrack Digital Recorder with a sampling rate of 44.1 kHz using an Audio-Technica head-mounted microphone. Participants included family, friends, neighbors, co-workers, and other acquaintances of local contacts. All speakers were born and raised in the Rio de Janeiro metropolitan area. The interviews were conducted by other natives of Rio de Janeiro, although I was also present during all of the interviews and occasionally contributed to the conversations.

The individual chapters give details about which phonetic environments were included in the analyses. For both chapters, all available tokens of the vowels in stressed syllables in these environments were analyzed, with the following exceptions. The first five minutes of each interview were excluded, since participants are more likely to be nervous or uneasy during this portion of the interview. Vowels shorter than 60 ms were not included, since there would not be enough formant measurements to analyze

diphthongization in such vowels. Vowels longer than 500 ms were also excluded, since these tend to be exaggerated pronunciations and thus could bias the results for some vowels. Finally, vowels after glides and liquids were not included since the presence of these sounds tends have a strong effect on the formants of surrounding vowels. In Brazilian Portuguese, these include /j/, /w/, /l/, and /ʎ/.[1]

3.1 Phonetic Analysis

All of the data were analyzed using the Praat program. In Chapter 4, which examines the effect of the phonetic environment on the formant transitions of the preceeding vowel, measurements were taken at the midpoint of the vowel and at 25 ms from the endpoint. Since most of the vowels examined in this way are monophthongs, this type of analysis is well suited to the purpose of illustating how different environments affect the formants. In Chapter 5 however, where diphthongal vowels are the main concern, this type of analysis is less appropriate, since examining only two points in the vowel (midpoint and 25 ms from the endpoint) fails to capture the complexities of diphthongs.

The issue of how to analyze diphthongal vowels requires some consideration, since several methods of measuring diphthongs have been employed in sociolinguistic and phonetic studies. Many studies have attempted to locate steady states for both the onset and the glide, although methods vary as to how the steady states are defined. Most locate the steady state by visually inspecting the spectrogram to estimate when the formants appear to be parallel or when one or more of the formants begins to change (Blake & Hjosey, 2003; Fridland, 2000; Kerswill et al., 2008). When no steady state is available, studies typically take measurements at the minimum or maximum formant values, as is appropriate for the particular diphthong in question (Cox, 2006;

[1] "r" in Brazilian Portuguese is not a liquid—it represents two phonemes, /ɾ/ and /x/.

Maclaganand & Hay, 2007). Other studies have avoided the issue of steady states by measuring formants at multiple points in the vowel. These may be in terms of a specific time from the onset and offset of the vowel, such as 25 ms (Irons, 2007) or 35 ms (Dubois & Horvath, 2003), or at certain percentages of the duration of the vowel (Jacewicz et al., 2006).

The methods involving steady states lack a precise definition of how the steady states should be defined, since visual inspections of the spectrogram are subjective and can lead to inconsistencies from one researcher to another. Measuring formants at pre-defined points in the vowel produces more replicable results, although there is no consensus on what those points should be. Furthermore, some studies have shown that steady states and glide durations may be important characteristics of diphthongs (see Thomas 2002 for summary). My own data shows a large amount of variability in the presence or absence of steady states and well as in the duration of the glides. Since this variation may turn out to be an important way of distinguishing vowels along the monophthong-diphthong continuum, I opted for a method that will allow steady states and glide durations to be measured.

Measurements for the first three formants were taken at 6.25 ms intervals (the default interval in Praat), excluding the first and last 25 ms. Duration was measured from the first zero crossing at the beginning of periodic energy to the last zero crossing at the end of periodic energy of the vowel. The formants were generated automatically in a Praat script, using the Burg method. The measurements were then verified for accuracy by comparing the formants found by Praat to the spectrogram. Praat sometimes finds spurious formants; in these cases, the measured value for F2 may actually be F1, and the measured F3 may be F2. Such errors were corrected manually. The F3 values were not used in the analysis; they were only measured to help with error corrections. Typically, the maximum formant value was set at 5000 Hz for men

and 5500 Hz for women. If Praat was not able to accurately trace the formants of any particular token with these values, values ranging from 4000 Hz to 6500 Hz were used to provide the best fit. Vowels in which Praat was not able to accurately trace the formants were not included in the analysis.

The onset of the vowel was defined as the point that minimizes the difference F2 – F1. Since the glides in the vowels under investigation typically move toward [i], F1 generally falls and F2 generally rises. Thus the minimum F2 – F1 difference provides a reliable way to locate the portion of the vowel that is farthest away from the end point of the glide. In many cases, this point was at 25 ms, the first measured point in the vowel; in these cases, no steady state is defined. The offset of the glide was defined as the point that maximizes the difference F2 – F1, that is, the point that is closest to [i] in the vowel space. The glide intensity was defined as the Cartesian distance between the onset and the offset of the glide.

To help estimate the point where the formants begin to change, equations 3.1 and 3.2 where used, where ϵ represents a threshold, and $t_1, t_2, \ldots, t_n$ represent the time intervals at which the formants were measured (every 6.25 ms).

$$G(t_i) = \sum_{i=2}^{n} max\{\epsilon, |F(t_i) - F(t_{i-1})|\} - \epsilon \tag{3.1}$$

$$G(t_1) = 0 \tag{3.2}$$

Thus for all of the time intervals starting with the second interval, the absolute value of the difference between two consecutive intervals' formant values was calculated, ignoring any difference less than the threshold. The threshold used was 25 Hz; although arbitrarily chosen, using a consistent threshold allows for the all of the data to be compared. The steady states were defined as the portion or portions of the vowel in which the change in F1 and F2 between each measured interval is less than

the threshold. A vowel may have no steady states, meaning the formants change rapidly throughout the duration of the vowel, or many steady states. In the later case, the longest steady state near the minimum F2 – F1 difference was used. Praat scripts were used to perform the calculations shown in equations 3.1 and 3.2 and to find the steady states.

The starting point of the glide was defined as the last time interval of the steady state, that is, the point at which the formants begin to change at a rate faster than the threshold. To allow for the comparison of different vowels, this point was expressed as a percentage of the duration of the vowel (not including the first and last 25 ms, since these portions of the vowel were not analyzed). Thus, tokens in which the formants begin to change at 25 ms (the first measured point) the starting point of the glide would be 0%. Tokens in which the glide intensity was less than 100 Hz were considered monophthongal, and the starting point of the glide was defined as 100% (thus indicating no glide present.)

3.2 Normalization

Normalization of formant values poses a challenge, especially when not all the vowels in the vowel space are being analyzed. Most of the methods available work best when all vowels are included (Thomas & Kendall, 2007), but this study only focuses on back vowels, and for many speakers, just /a/. The formant values were normalized using the formula shown in equation 3.3, adapted from Miller et al. (1980), where F_i represents the average formant values for a given vowel.

$$F_{i(NORM)} = log\ \frac{F_i}{\sqrt[3]{F1 \cdot F2 \cdot F3}} \tag{3.3}$$

For the sake of normalization, vowels before word-final /S/ and vowels before non word-final /S/ were treated separately, since the former tend to be fronted and/or

raised for most speakers. Onsets and offsets were normalized as if they were separate vowels. The advantage of this normalization technique is that it does not require input from all vowels in the system. Given the resources available and the number of speakers in this study, analyzing the entire vowel space for each speaker was not feasible.

Ideally, normalization should eliminate physiological differences among speakers while preserving sociolinguistic differences and also preserving the phonological distinctions among different vowels. The technique used was fairly successful in maintaining phonological distinctions among the various /a/ vowels, but for most speakers it failed to do so for the back vowels. The vowel chart for Romero, which is provided in Figure 3.1 with both normalized and non-normalized values, is a typical example. (The # symbol indicates checked vowels in these charts).

For the /a/ and /ai/ vowels, normalization nearly perfectly maintained the distinctions among the vowels; the only difference is normalized PAIS is slightly more fronted than FAZEM, though it is actually slightly raised and backed. The distinctions among the back vowels, however, are not at all maintained. Checked /oi/ and /o/ are much too fronted in relation to /a/ and /ɔ/, while checked and open /ɔ/ have not only switched positions on the F2 scale, they are too low and fronted. The reason for this contrast in the normalization of the low central vowels and the back vowels is unknown. It may be due to the F3 values, or perhaps a result of rounding, which tends to lower F2 and F3 (Stevens, 1998). If the data were limited to /a/ and /ai/ this normalization technique would be acceptable, but for the other vowels it is obviously inadequate.

For this reason, the normalization technique was modified. Two vowels for each of the first two formants were selected as "anchors," meaning that their normalized scores calculated in equation 3.3 were used without modification. The remaining

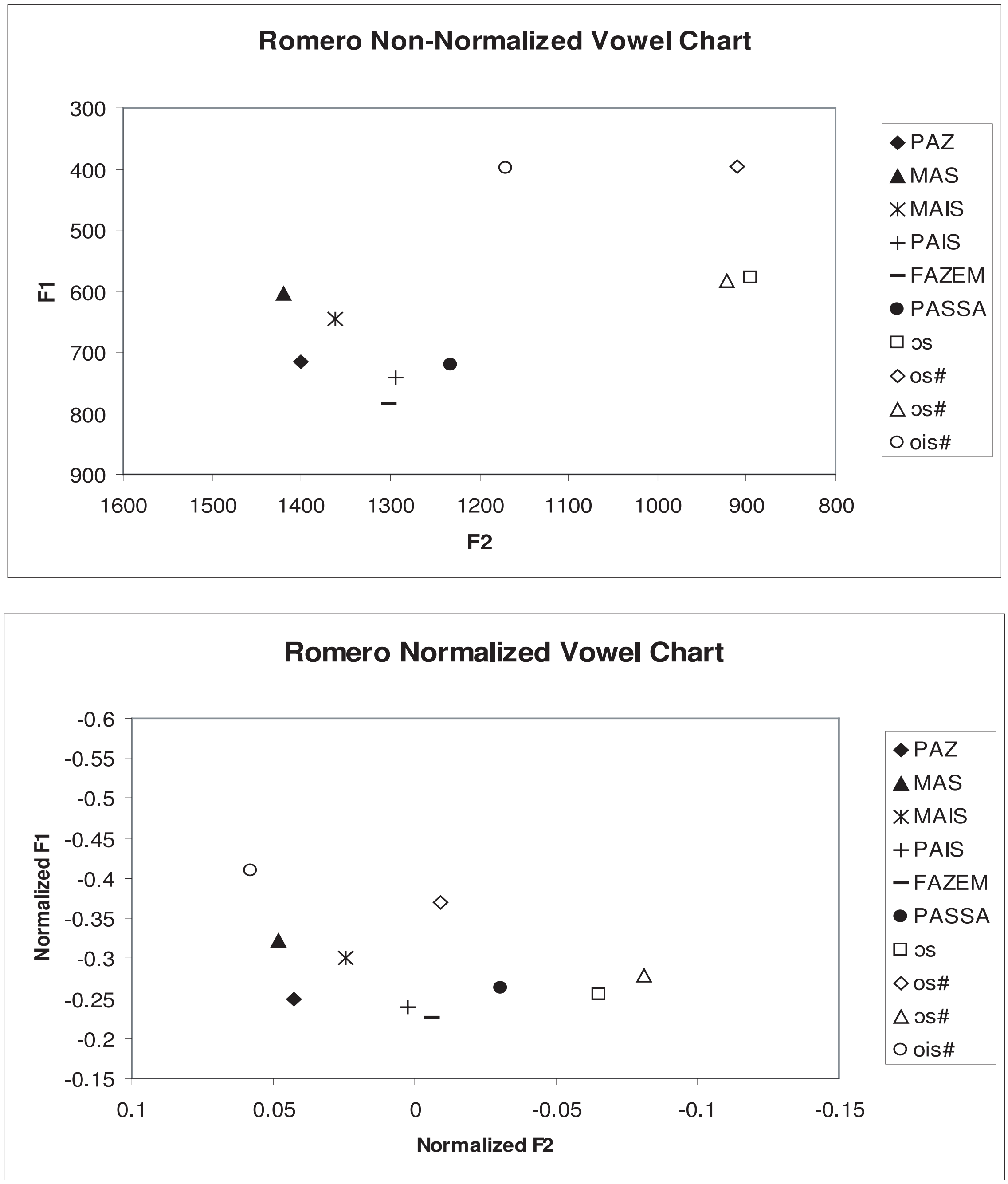


Figure 3.1 : Vowel charts illustrating the difference between normalized and non-normalized vowels.

non-normalized formant values were then rescaled based on the normalized scores of the anchors and the distance between them. This allows the data to be normalized without distorting the phonological distinctions among different vowels. The formulas used for rescaling are given in equations 3.4 and 3.5, where F is the formant value to be normalized, A_1 and A_2 are the non-normalized formant values for the two anchors, and $A_{1(NORM)}$ and $A_{2(NORM)}$ are the normalized scores for the anchors. (The two anchors are selected independently for each formant; A_1 and A_2 do not correspond to F1 and F2).

$$F_{(NORM)} = A_{(NORM)} - scale(A - F) \tag{3.4}$$

$$scale = \frac{A_{1(NORM)} - A_{2(NORM)}}{A_1 - A_2} \tag{3.5}$$

In the case of equation 3.4, either A_1 or A_2 values can be used for A and A_{NORM}—the result is the same. The anchors themselves were selected automatically with a computer program. The program first rescales the normalized and non-normalized values to a common scale using all possible combinations of two anchors. The common scale was obtained by substituting 0 for A_1 and 100 for A_2 in equations 3.4 and 3.5. The values 0 and 100 are arbitrary—any two values could be used as long as they are used consistently. Next, the distance between each vowel's normalized value and non-normalized value is calculated. The "best" anchors are the ones that minimize the sum of these distances. This eliminates the risk of using anchors that are not well normalized–that is, values that are too high or too low in relation to other values. A potential problem arises, however, if vowels are included for which not all speakers have data. In order to be effective, all vowels must have an equal chance of being selected as anchors, otherwise some speakers' normalized scores could be skewed. For this reason, only those vowels for which data is available for all 36 participants were

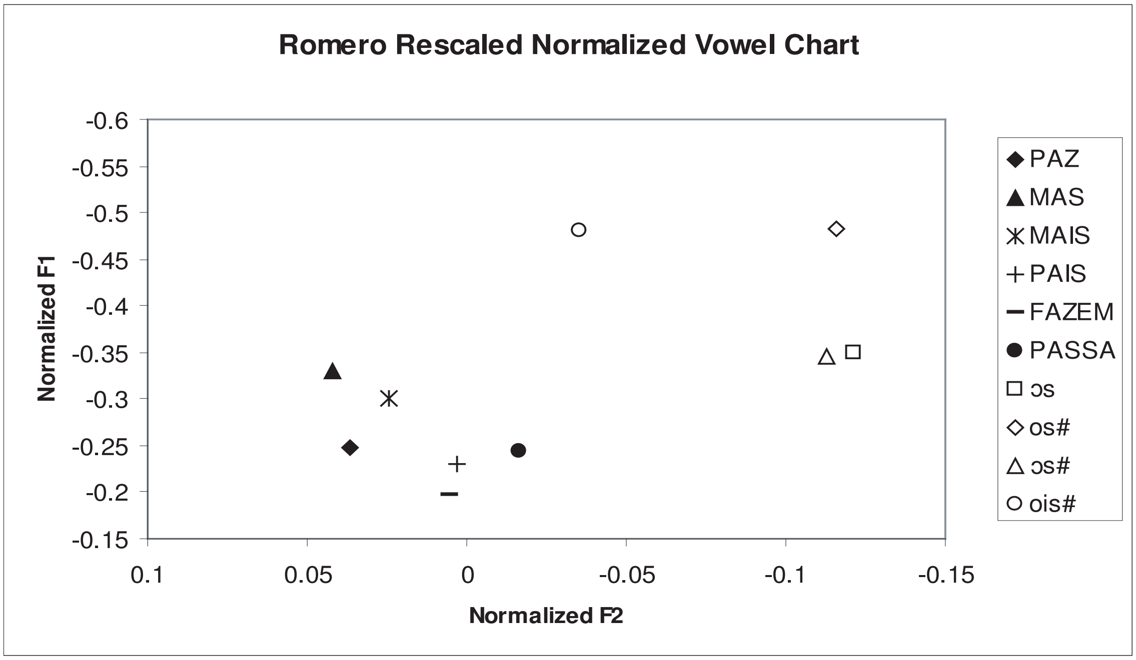


Figure 3.2 : Example of a rescaled normalized vowel chart.

used as possible anchors. This includes MAS and MAIS plus their offsets. (Offsets were normalized as if they were separate vowels.) Once all the vowels were normalized using this method, a normalized value for the Cartesian distance between the onset and offset was calculated based on the normalized scores.

The main advantage of this method is that it is as effective as Miller et al.'s (1980) method at eliminating physiological differences between speakers, but phonological distinctions among vowels are always maintained. The rescaled vowel chart for Romero is shown in Figure 3.2 as an example. The positions of the vowels in relation to each other are identical to those in the non-normalized chart in the top half of Figure 3.1—but the normalized scale is identical to that of the normalized chart in the bottom half of Figure 3.1.

One potential disadvantage of this method is that it probably does not model the cognitive processes that allow human listeners to perceive vowels uttered by different

speakers. But since there is currently no consensus on how humans do this (cf. Pisoni 1997 and Rosner & Pickering 1994), this is not necessarily a drawback in comparison to other methods.

3.3 Social Variables

The social variables examined in this study are age, speaker sex, and socioeconomic class. Defining the age and sex for each speaker is straightforward; class, however, is determined by considering several factors. As showed is section 2.4, one strong indicator of class in Brazil is whether one lives in a favela or in a house/apartment. Seven of the participants in this study live in a favela in Niterói, a suburb of Rio de Janeiro. These contacts were made through a church, in which some of the members were known to live in a nearby favela. Additional interviews were obtained from the neighbors of these initial contacts. These participants provide the core of the data for the lower/working classes. Other participants were assigned to the lower or working class based on their occupation type and educational level, even when information about their housing type is not known. Unfortunately, it is not always easy to determine whether someone in Brazil lives in a favela. Asking about one's housing type is of little help, because all favela residents would say they live in a house. In Rio de Janeiro, members of all classes live in both houses and apartments, so this information alone says nothing about one's socioeconomic status. Because living in a favela is strongly stigmatized in Brazil, few people would name a specific favela if asked where they live. It could also be offensive to ask someone whether they live in a favela. Information about one's neighborhood is of little use, because most neighborhoods in Rio have nearby favelas. Unlike most cities, the wealthy and the poor in Rio usually live in very close proximity. Thus it is necessary to rely more on other factors, namely occupation type and educational level, to determine

the socioeconomic class of most participants.

Table 3.1 summarizes the important information about each participant in this study.[2] Since the data were gathered from semi-structured interviews (as opposed to questionnaires), some information (such as housing type) is not available for all speakers. Data of the profession and educational level are given for all participants, as these are the most important factors used in determining each person's class. All known family relationships among the participants are also noted, as this may also be an important factor. Other information that arose from the interviews, such as family background, goals, and aspirations, were also taken into consideration when determining each participant's class.

The educational system in Brazil contains three levels, roughly equivalent to "Elementary school," "High school," and "University" in the United States; these are the terms used in the table. In Brazil, there are numerous terms in use due to changes in the terminology. When asked about their educational level, participants usually respond with the terminology that was in use when they were in school. *Ensino Básico*[3] or *Ensino Fundamental*, formally called *Primeiro Grau* or *Ginásio*, corresponds to "Elementary school" in the table. It goes through eighth grade (*oitava série*). *Ensino Médio*, also called *Colégio*, and formerly called *Ensino Secundário* or *Segundo Grau*, corresponds to "High school." It includes three years of study. *Formação Técnica*, similar to vocational school in the U.S., but less stigmatized as a career choice, is also included in this category. *Ensino Superior*, also called *Universidade*, and formerly called *Terceiro Grau*, corresponds to "University."

[2]To help protect the anonymity of the participants, all names are pseudonyms and ages are approximate.

[3]Technically, *Ensino Básico* refers to both *Ensino Fundamental* and *Ensino Médio*, although most people use it only in reference to *Ensino Fundamental*.

Speaker	Sex	Age	Housing type	Profession	Education	Class	Relationships
Alberto	M	40	House	General services in a health club/Street seller	High school (incomplete)	Lower/Working	Cláudia's father
Ana	F	25	Unknown	University student (communications, publicity)	University (studying)	Middle	
Beatriz	F	40	Favela	Street seller	Elementary school	Lower	
Bruna	F	20	Unknown	University student/Teacher	Post-graduate (studying)	Middle/Upper	
Camila	F	25	Unknown	University student (computer science)	University (studying)	Middle	
Carolina	F	25	Unknown	Journalist	University	Middle	
Cláudia	F	15	House	High school student (wants to be teacher)	High school (studying)	Working	Alberto's daughter
Donato	M	20	Unknown	University student/Journalist	University (studying)	Middle	
Fabiana	F	50	House	Accountant	High school	Middle	Romero's mother
Geraldo	M	30	House	Stocker in supermarket	High school	Working	
Helena	F	45	Apartment	Psychologist	University	Upper	Salina's mother, Vitória's sister
Humberto	M	30	Unknown	Assistant librarian	High school	Working	
José	M	20	Favela	High school student/Administrative assistant	High school (studying)	Working	Juliana's son
Juliana	F	50	Favela	Homemaker (Used to be street cleaner)	Elementary school	Lower	José's mother
Laura	F	20	Unknown	University student (language arts)	University (studying)	Middle	
Leonardo	M	40	Unknown	Janitor/General services in a library	Elementary school (6th grade)	Lower	
Liana	F	20	Unknown	University student	University (studying)	Middle	
Lucas	M	20	Unknown	University student (communications, journalism)	University (studying)	Working/Middle	
Luisa	F	50	Unknown	Secretary	University	Middle	
Maria	F	40	Unknown	Teaching assistant	University (incomplete)	Middle	
Marta	F	25	Favela	Unemployed	High school	Lower/Working	
Mateus	M	25	Unknown	University student (marketing)	University (studying)	Middle	
Olívia	F	40	Apartment	Public worker	High school	Middle	Rita's daughter
Oscar	M	20	Unknown	Assistant librarian/Copy machine operator	High school (incomplete)	Working	
Paula	F	20	Favela	High school student	High school (studying)	Lower/Working	
Paulo	M	40	Unknown	Assistant librarian	University (incomplete)	Working	
Pedro	M	25	Unknown	Administrative assistant in a university	University	Middle	
Priscila	F	20	Favela	High school student	High school (studying)	Lower/Working	
Rita	F	75	Apartment	Homemaker	High school (incomplete)	Working	Olívia's mother
Romero	M	20	House	University student (information sciences)	University (studying)	Middle	Fabiana's son
Salina	F	15	Apartment	High school student	High school (studying)	Upper	Helena's daughter
Sofia	F	35	Unknown	University student (Portuguese and English)	University (studying)	Middle	
Susana	F	40	Favela	Street seller	Elementary school (5th grade)	Lower	
Taís	F	20	Unknown	University student/Teaches English	University (studying)	Middle	
Tiago	M	55	Unknown	Security guard	Elementary school (5th grade)	Lower	
Vitória	F	35	Apartment	Biochemist	Masters	Upper	Helena's sister

Table 3.1 : Summary of participants

The class system used in this study is based on the one shown in Table 2.2, from Ribeiro & Scalon (2003), with a few modifications. The rural classes are not used, since all of the participants in this study are urban. In addition, the "Petit bourgeoisie" category is not used, since no participants seem to fit into this category. (Ribeiro & Scalon define it as small business owners and those who are self-employed.) Most importantly, the names of the categories have been changed to correspond to those typically used in sociolinguistic studies. "Upper class" refers to "professionals, administrators, and managers," "middle class" refers to "non-manual routine workers," "working class" refers to "skilled manual workers," and "lower class" refers to "non-skilled manual workers." Many jobs in Brazil, such as doormen and security guards who do not operate weapons, are non-manual but also non-skilled. These may be either working class or lower class, depending on other circumstances, such as their educational level. Using this terminology serves to distance the class system from one based entirely on job type to one based on a combination of job type, educational level, and housing type (favela vs. non-favela). Thus in some cases, the class assigned to the participant may not correspond to the job types outlined in Ribeiro & Scalon's system.

The decisions about which class to assign to each participant were made qualitatively, rather than simply as a combined index based on other variables, as used in studies like Labov (2001). The advantage of this type of classification is that it allows for other factors to be taken into consideration, such as a participant's background or aspirations, and it allows for in-between categories to be made for cases where participants seem to have characteristics of more than one class.

The upper class participants include two professionals, who are sisters: Helena, a psychologist, and Vitória, a biochemist. Salina is also assigned to the upper class partly by virtue of being Helena's daughter. She was a high school student at the time

of the interview, attending a prestigious school that prides itself in producing some of Brazil's greatest intellectuals and politicians. Thus it is likely that she will continue in the same class as her mother. Bruna is assigned to both the middle and upper classes since she is a post-graduate student, as this puts her educational level above all of the other middle class participants. There are numerous university students in the study. Most of them have been assigned to the middle class, given their high level of education. One exception is Lucas, who is assigned to both the working and middle classes. He comes from a poorer family than the other university students and is working to pay for his education. Thus he appears to be an example of someone who not only aspires to be in a higher class than that of his parents, but has a good chance of achieving this goal.

Rita is the oldest participant in the study, at 75 years old. Although she does not have much education (she did not finish high school), she grew up during a time when women in Brazil were not expected to study and pursue careers (she was a homemaker all her life). Thus her class was assigned based on her husband's occupation. He was a mechanic in a automobile factory, a typical working class profession.

Typical middle-class jobs represented in the study are Journalist (Carolina), Accountant (Fabiana), Secretary (Luisa), Public Worker (Olívia), and Administrative assistant (Pedro). Note that in Brazil, it is not necessary to have a university education to have one of these types of jobs, since as an alternative to a regular high-school, people have the option of going to a vocational school (Ensino Técnico), which prepares one for a specific career.

There are two cases of participants who are not university students, but who have some university education (i.e. they attended a university but did not finish). Maria was studying to become a physical therapist, but decided to quit to be able to stay home and raise her children. She only recently returned to work. Her job as

a teaching assistant seems to put her in the middle class. The case of Paulo is quite different. He studied physical education for four terms in a university as an adult but could not finish for financial reasons. His job as a assistant librarian (he checks people's bags as they enter and exit the library) is non-skilled, but he is interested in going back to school to study *biblioteconomia* "library studies." Thus he seems to have characteristics of both the middle class (he has some university education) and the lower class (he has a non-skilled job). Given his educational level and aspirations, he was assigned to the working class. Of the other assistant librarians in the study, Humberto and Oscar, Humberto is close to Paulo in educational level (he finished high school, but did not go to university). Oscar did not finish high-school, but his job is semi-skilled (he operates a copy machine). Thus they are both assigned to the working class. Tiago works as a *segurança*, which translates as "security guard," although his actual job description is more similar to that of a doorman for a building in a university. Given his educational level (he did not finish high school), he was assigned to the lower class.

The three favela residents over 40 years old (Beatriz, Juliana, and Susana) are typical members of the lower class. None has any high school education; Juliana is a homemaker, while the other two are *vendedores ambulantes*, people who walk around crowded areas selling food or small, inexpensive items. The younger favela residents all have more ambitious goals than those of previous generations, and all have at least some high school education. Marta is unemployed, but is taking many free courses, including English. Paula and Priscila are both very ambitious high school students and aspire to jobs typical of the middle class. However, given their poor background and the difficulties of obtaining free education beyond high school in Brazil, along with the inferior quality of the free public high schools, they have been assigned to both the lower and working classes. José already works part time as an administrative

assistant as he finishes high school, thus he has been assigned to the working class.

There are also several non-favela residents and participants whose housing type is not known who appear to be members of the lower and working classes based solely on their job type and education. Geraldo is a stocker in a supermarket, a typical working class job of skilled manual labor. Alberto was assigned to both the lower and working class, since is was unclear from his job description whether his job type is skilled or unskilled (he said he provides services to a health club and sells things on the street.) He went to high school, but did not finish. His daughter, Cláudia, is currently a high school student who wants to be a teacher. However, given her father's background, she was also assigned to the working class. Leonardo is a janitor who also "provides general services" in a library. Given his educational background (he did not finish elementary school) these are likely to be unskilled services, thus lower class seems most appropriate for him.

Chapter 4

Phonetic Analysis

This chapter presents a detailed phonetic analysis of one speaker, Francina, a native of Niterói (suburb of Rio de Janeiro). She was a graduate student in her early twenties at the time of the interview. She worked part time as a secretary at her university to help pay for college. Although she was living and studying in Brazil, the interview was conducted while she was visiting the United States.

The purpose of this analysis is to gain an overall view of how the following environment affects each vowel in Portuguese, specifically how the following consonant affects the formant transitions between the midpoint of the vowel and 25 ms from the endpoint. This information will help explain why diphthongization tends to occur in some environments but not others. A subset of these vowels are analyzed in Chapter 5 for a larger sample of speakers to be able to show how they vary among different speakers.

Vowels were classified according to the following consonant with a separate category for word final vowels before a pause. In cases where there was no pause between word boundaries, word final stressed vowels were categorized by the consonant of the following word. For example the /ɔ/ of *só fui* /sɔfwi/ "I've only been" was included in the /f/ environment. Table 4.1 lists the number of tokens by following environment for Francina.

With the exception of word-final /S/, the following environment has been treated in terms of its phonetic (as opposed to phonemic) realization. For example, [ʧ] and [ʤ] are allophones of /t/ and /d/, occurring only after [i] (cf. *podem* [pɔdẽ] "they can"

Following Environment	Vowel /a/	/ɔ/	/o/
[p]	2	1	8
[b]	6	0	4
[f]	0	1	1
[v]	18	7	0
[t̪]	8	3	5
[d̪]	25	5	5
[s]	18	7	1
[z]	10	8	5
[ʧ]	1	2	0
[ʤ]	25	6	0
[ʃ]	5	5	1
[ʒ]	3	0	1
/S/#	13	2	0
[k]	5	5	7
[g]	4	0	0
[x]	1	0	0
pause	3	3	8
Total	147	55	46

Table 4.1 : Number of tokens analyzed for Francina by vowel and following phonetic environment.

vs. *pode* [pɔʤi] "he/she can"); however they were analyzed as palatoalveolar consonants. Since vowels in the word final /S/ environment behave differently than in other environments, vowels in this environment (labeled "/S/#") are treated separately.

Due to the uneven distribution of tokens within each environment, the environments were grouped as follows:

- Labial and labiodental ([p], [b], [f], [v])
- Dental ([t̪], [d̪])
- Alveolar ([s], [z])
- Palatoalveolar ([ʧ], [ʤ], [ʃ], [ʒ])
- Velar ([k], [g], [x])

4.1 Results

Two-tailed independent t-tests were used to compare the change in F1 and F2 between the midpoint and 25 ms from the endpoint for vowels preceding voiceless consonants with the change in F1 and F2 of their voiced counterparts. Only those for which there are at least two tokens in each environment were tested. Results indicate significant differences for the F1 of /a/ and the F2 of /ɔ/ in the case of the palatoalveolar fricatives. For /a/, the mean difference is 149 Hz for F1 ($SD = 47.3$; $p = .004$); for /ɔ/, the mean difference is 359 Hz for F2 ($SD = 64.7$; $p < .001$). In both cases, the vowels before /z/ showed more formant movement between the midpoint and 25 ms from the endpoint than those before /s/. Therefore, the /s/ and /z/ environments will be treated separately for /a/ and /ɔ/ while other voiced and voiceless pairs will be grouped together. Because there was only one token of /o/ before /s/, the /s/ and /z/ environments are combined for /o/.

Figure 4.1 is a vowel chart for Francina showing the average F1 and F2 values at both the midpoint and 25 ms from the endpoint for the vowels grouped by following environment.[1] Almost all environments (except for labials after /o/) show at least some effect on the formant transitions of the vowel at 25 ms from the endpoint. Formants show the least amount of movement in the following environments: pre-labial, pre-dental (for /o/), pre-alveolar-voiceless (for /a/ and /ɔ/), pre-velar, and pre-pause (for /a/). Large formant transitions for /a/, /ɔ/, and /o/ occur before palatoalveolar consonants, before /z/, and before word final /S/ (whose pronunciation may be [ʃ], [ʒ], [z], or [s]). The midpoint of /a/ and /ɔ/ in the word final /S/ environment is raised and fronted. Since vowels in this environment are typically diphthongal, this is in part due to the fact that the formants have already started to transition to the glide by the midpoint of the vowel. However, as shown in Chapter 5, even formant measurements taken near the onset of the glide often show fronting and raising as well.

Table 4.2 shows the results of an ANOVA test, comparing the F1 and F2 movements for each vowel. The test reveals a significant difference at $\alpha = .01$ among the environments for the movement of both F1 and F2 for /a/ and for the movement of F2 for /ɔ/ and /o/. Most of the glides move toward a high front target, in the direction of [i]. Since /a/ is a low central vowel, both F1 and F2 are affected, and since /ɔ/ and /o/ are mid back vowels, most of the change occurs in F2 rather than F1. The vowel chart showing both the midpoint and the glides in Figure 4.1 provides a visual representation of this same information.

[1] To increase the readability of the chart, some environments have been omitted. /ɔ/ pre-alveolar-voiceless overlaps with the /ɔ/ in the pre-dental environment. /o/ pre-velar overlaps with the /o/ in the pre-palatoalveolar environment. Neither show glide movement of more than 50 Hz for either formant.

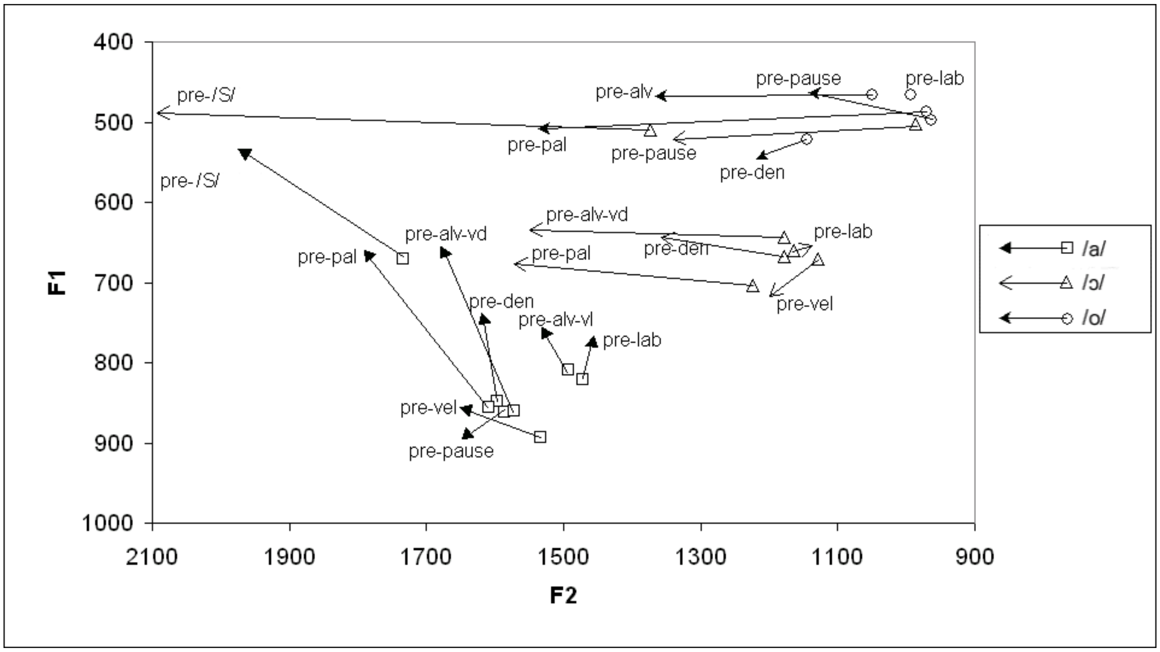


Figure 4.1 : Vowel chart for Francina, showing the average F1 and F2 values at the midpoint and 25 ms from the endpoint for vowels grouped by following environment.

Vowel	Formant	F	Sig.
/a/	**F1**	3.657	**p = .001***
	F2	6.479	**p < .001***
/ɔ/	F1	0.277	p = .960
	F2	14.337	**p < .001***
/o/	F1	0.865	p = .513
	F2	9.231	**p < .001***

Table 4.2 : Results of ANOVA test of the difference in formant movements between the midpoint and 25 ms from the endpoint among tokens grouped by following phonetic environment (*Significant at $\alpha = 0.05$)

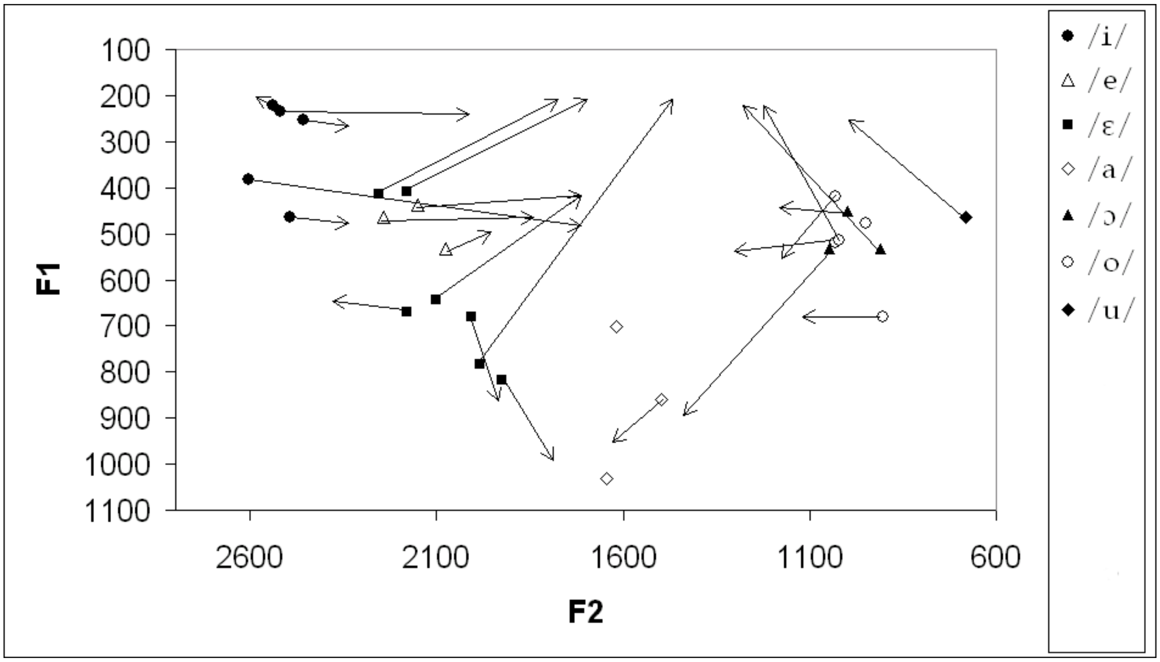


Figure 4.2 : Vowel plot for Francina showing glide movement in stressed word final vowels before a pause (individual tokens).

Due to a large amount of variation, Figure 4.1 may be misleading in its representation of word final vowels before a pause. Both /ɔ/ and /o/ show long off-glides in this environment, and data from other Portuguese vowels shows that it is not unique to these vowels. Figure 4.2 shows tokens for all word final stressed vowels before a pause. Individual tokens are used instead of averages in order to show the variation in the length and direction of the off-glide. The chart shows that all vowels except /a/ have examples of long off-glides in word final stressed position before a pause. Most of the diphthongal tokens have glides moving toward the center of the vowel space, though some move toward high-center, others toward mid-center, and others toward low-center.

4.2 Discussion

The development of offglides appears to be strongly related to coarticulation of the vowel and the following consonant. The formant transitions tend to move in the expected direction for each environment. Vowels in the pre-labial environment in Francina's vowel chart (Figure 4.1) show the least amount of movement. A constriction of the vocal tract at the lips tends to cause all formant frequencies to decrease (Stevens, 1998). However, since back vowels already have a low F2, there is typically little movement of the second formant in this environment. Francina's vowel chart shows a slight decrease of F1 for pre-labial /a/.

For vowels in an alveolar environment, formant transitions are most pronounced for back vowels, thus it is not surprising that /a/, /ɔ/, and /o/ in this analysis have long glides before [z]. According to Stevens (1998), back vowels in an alveolar environment have a raised F2, and for a low back vowel (i.e. /a/) a lowered F1 as well. The significant difference found for vowels before the voiced and voiceless alveolars [s] and [z] may be related to the fact that vowels tend to be longer before voiced consonants. Indeed, Francine's vowels before [z] are on average 60 ms longer than those before [s] (174 ms vs. 114 ms).

The stops /t/ and /d/ in Portuguese are normally dental, not alveolar as in English. According to Ladefoged & Maddison (1996) the second formant is lower in this environment than in the alveolar environment. Thus for back vowels, which have a low F2, one would not expect as much formant movement, and indeed the pre-dental vowels for Francina tend to have shorter glides than the pre-alveolar and pre-palatal vowels. The formant transitions for pre-palatal vowels should be longer for those of pre-alveolar vowels since the constriction is further back in the mouth. The data for Francina indeed show this pattern.

F1 and F2 transitions for vowels in velar environments are similar to those for

alveolar consonants, although Stevens (1998) notes the formants do not move as rapidly near the closure when the constriction is made with the body of the tongue as opposed to the tip or blade. The vowels analyzed in this study do not show much formant movement in pre-velar environments.

Since there is no following consonant, the formant transitions in the pre-pause environment cannot be explained in terms of coarticulation. It is also in this environment that the direction of the glide is less predictable. F2 tends to rise for back vowels, while for front vowels, F2 tends to fall. F1 may rise or fall for any given vowel. Thus the glides in these tokens tend to move in the direction of the central vowels [a], [ə], or [ɨ]. This may be due to the tongue moving toward its resting position before the voicing of the vowel has ceased. The presence of this type of glide appears to be common in Rio de Janeiro and is particularly noticeable when answering the phone (*alô* [aloə]) and in the word *é* [ɛə] "it is" when used as a form of backchanneling.

The analysis of Francina's vowels helps explain why diphthongization in pre-palatal and pre-alveolar environments is common in Portuguese, both diachronically and synchronically. It appears to be related to coarticulation of the vowel and the consonant. While formant transitions within 10 ms of closure are due almost entirely to tongue movement in anticipation of the following consonant, formant transitions before 25 ms can have an audible difference in vowel quality. Thus diphthongization as a conditioned change can be thought of as a process in which the formant transitions normally present toward the end of the vowel begin to dominate the middle region of the vowel, and in extreme cases, even the entire vowel. As is shown in Chapter 5 in the case of pre-alveolar vowels, this process can be seen synchronically when the start of formant change is compared across successive generations, with younger speakers showing formant transitions sooner in the vowel than older speakers.

A larger sample of speakers is necessary to show individual differences in the

degree to which the environments favor diphthongization. Thus, the next chapter will consider social factors to help explain this variation, focusing on the vowels in the pre-alveopalatal and pre- word final /S/ environments, since these occur frequently in natural conversation and tend to show a large amount of variation in the community.

Chapter 5

Variation Analysis

This chapter examines variation in the diphthongization of back vowels before word-final /S/ for 36 participants, all of whom were born and raised in the Rio de Janeiro metropolitan area. The focus is on /a/ and /ai/, by far the most frequently occurring vowels in this environment, particularly in the words *mas* "but" and *mais* "more." Because the words *mas* and *mais* are high-frequency function words, they make up the bulk of the data for most speakers. However, being function words, they are also more likely to be phonetically reduced than non-function words like *paz* "peace" and *pais* "parents." In addition, most of the /ai/ diphthongs other than *mais* result from either the plural formation of words ending in -*ai* (as in the case of *pais*) or -*al* (in which the final -*l* is always vocalized, eg. *hospital* [sg.], *hospitais* [pl.]). This, combined with the fact that *mas* was historically in a different word class than words like *paz* (see Section 2.6), suggest that both *mas* and *mais* should be analyzed separately. To simplify the terminology, MAS and MAIS are used to refer to those specific words, while PAZ and PAIS are used to refer to all other words with /a/ and /ai/ before word-final /S/. In addition, ten tokens each per speaker (or as many as were available) of words before non word final /s/ and /z/ in open syllables were included for comparison. These are referred to as PASSA and FAZEM ("pass" and "they do", respectively). The term *checked /a/* is used to refer collectively to MAS and PAZ, while *checked /ai/* refers to MAIS and PAIS, and *open /a/* refers to PASSA and FAZEM.

Words containing /ɔ/, /o/, and /oi/ in the pre-/S/ environment occurred much

less frequently in the data; thus, these will be examined only for those speakers who produced at least three tokens of /oi/ and at least three token of either /ɔ/ or /o/ (or both). In addition, tokens of /ɔ/ and /o/ before non word final /s/ and /z/ (when available) were included for comparison. Words containing the /ɔi/ diphthong, such as *faróis* "headlights," are rare and did not occur at all in the data. Likewise, the high back vowel /u/ was also not analyzed due to a lack of data. The most frequently occurring word with /u/ in the pre- word-final /S/ environment is *luz* "light", and since the vowel occurs after a liquid in this case, it was not included. The /ui/ diphthong in this environment is even more rare: it is mainly found in the plural of words ending in *-ul*, such as *azuis* "blue (pl.)".

Because /ɔ/ and /o/ are not consistently distinguished in Portuguese orthography, IPA symbols are used instead of word types to refer to these vowels in order to avoid confusion for those who are not familiar with the language. As before, "checked" refers to those before word-final /S/, and "open" refers to those before non word-final /s/ or /z/. Thus the possible types of vowels are: checked /ɔ/ (eg. *nós* "we"), checked /o/ (eg. *arroz* "rice"), checked /oi/ (eg. *dois* "two"), open /ɔ/ (eg. *nosso* "our", *perigosa* "dangerous [fem.]"), and open /o/, (eg. *fosse* "were [subj.]", *doze* "twelve").

Vowel charts showing /a/, /ai/, and if available, /ɔ/, /o/, and /oi/ for each participant are included in Appendix A. These will be referred to throughout the chapter to illustrate various points.

5.1 /a/ and /ai/

As explained in Chapter 3 (Section 3.1), there are numerous ways in which diphthongs can be analyzed. They can differ by their onsets, offsets, glide intensities, steady state patterns, etc. This section compares /a/ and /ai/ using each of the parameters outlined in Chapter 3. Those that correlate with social factors are also examined.

An ANOVA test was used to determine how the /a/ and /ai/ vowels varied by age, sex, and social class. The class variable was coded as lower = 1, working = 2, middle = 3, and upper = 4; participants who showed characteristics of more than one class were coded as lower/working = 1.5, etc. To simplify the graphs illustrating class differences, however, these in-between classes were included with the higher class, thus lower/working is included in the working category. The linguistic factors included in the analysis were: F1 and F2 of the onset and offset, Cartesian distance between the onset and offset, and start of formant change. Table 5.1 shows the results for the onset of F1 and F2; only those significant at $\alpha = 0.05$ are shown. The factors related to glides (offsets, Cartesian distance, and start of formant change) are examined in Section 5.1.2.

5.1.1 Onsets

The diphthongal vowels in this study vary considerably in terms of their positions in the vowel space. Checked /a/ and /ai/ are not only more diphthongal than open /a/, they are also more fronted and raised for most speakers. The average difference in onset F1 between checked /ai/ and open /a/ in this study is 68 Hz, and the average F2 difference is 50 Hz. For checked /a/ and open /a/, the difference is even greater: 120 Hz for F1, and 119 Hz for F2. Thus checked /a/ is even more fronted and raised than checked /ai/ for most speakers. Individual speakers vary in the amount of fronting and raising, and, as shown in Table 5.1, several vowels correlate with certain social factors in terms of their F1 and F2 onsets.

5.1.1.1 Age

Age was the most important social factor, both in terms of the level of significance of the correlations and the number of variables with which it correlates. Figures 5.1

Source	**Dependent Variable**	**F**	**Sig.**
Age	MAS Onset F2	18.884	.000
	MAIS Onset F1	7.294	.015
	MAIS Onset F2	14.790	.001
	PAIS Onset F2	6.115	.024
	PASSA Onset F2	6.645	.020
	FAZEM Onset F1	8.629	.009
	FAZEM Onset F2	14.557	.001
Class	MAIS Onset F1	13.670	.002
	MAIS Onset F2	7.413	.013
	PASSA Onset F2	7.124	.016
	FAZEM Onset F2	4.931	.040
Sex	MAS Onset F2	6.633	.020

Table 5.1 : ANOVA results showing significant correlations between vowel onsets (F1 and F2) and social variables (age, class, sex)

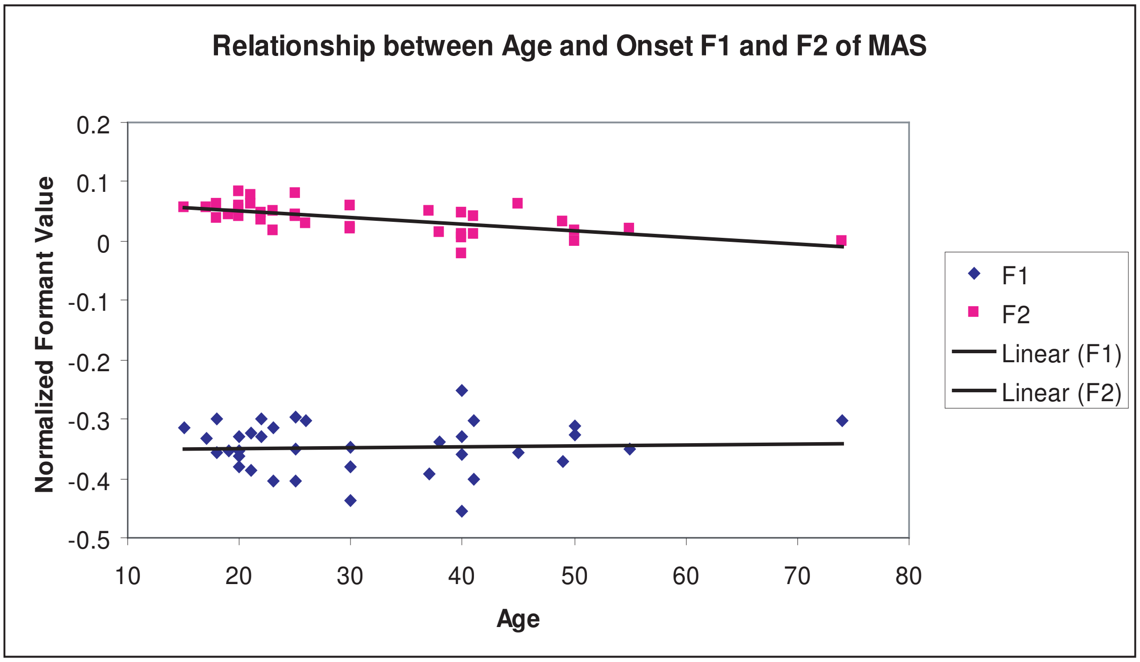


Figure 5.1 : Chart showing the relationship between age and the onset F1 and F2 of MAS.

through 5.4 show the relationship between age and the onset formants of MAS, MAIS, PAIS, and FAZEM. Although the relationship between F1 and age was not significant in all cases in the ANOVA (it was significant for MAIS and FAZEM, but not MAS and PASSA), F1 is shown on all the charts because it helps in interpreting the relationship between F2 and age. In all four cases, F2 tends to be higher among younger speakers, suggesting that these vowels are becoming increasingly fronted. However, in PAIS and FAZEM, F1 also tends to be higher among younger speakers. Since /a/ and /ai/ are already low vowels, it seems unlikely that they are becoming increasingly fronted and lower among younger speakers. A more likely explanation is that the difference is a physiological one that normalization failed to correct for. The fact that some studies have found that F1 tends to decrease with age due to changes in vocal tract configurations (eg. Xue & Hao 2003) supports this idea.

MAS and MAIS show a different pattern from PAIS and FAZEM. Although the

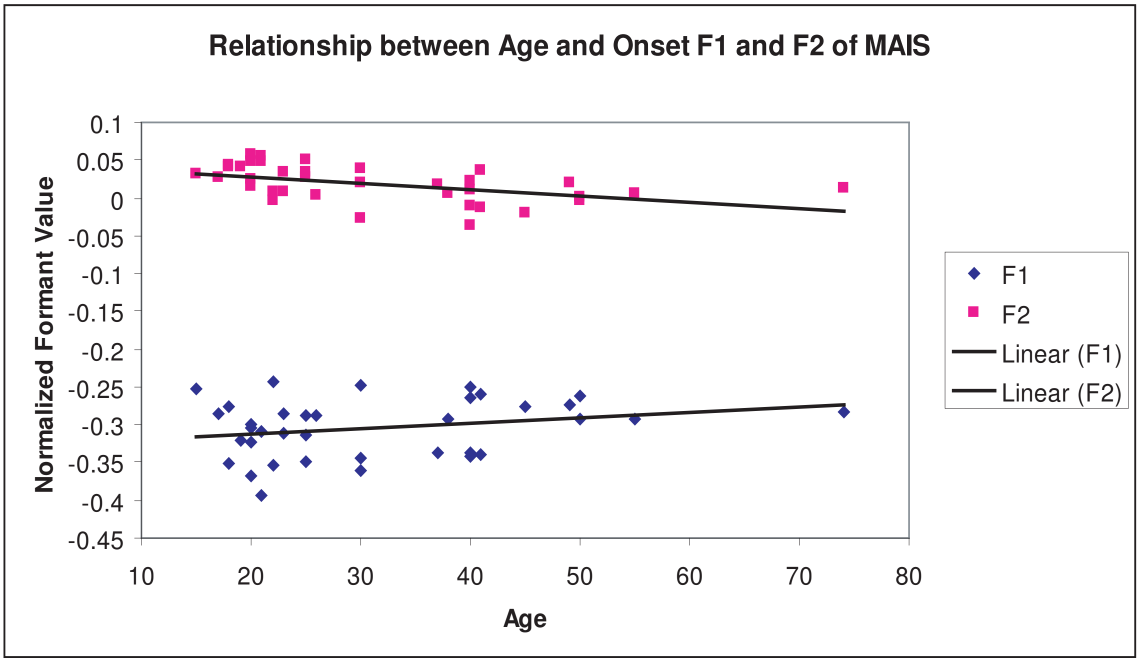


Figure 5.2 : Chart showing the relationship between age and onset F1 and F2 of MAIS.

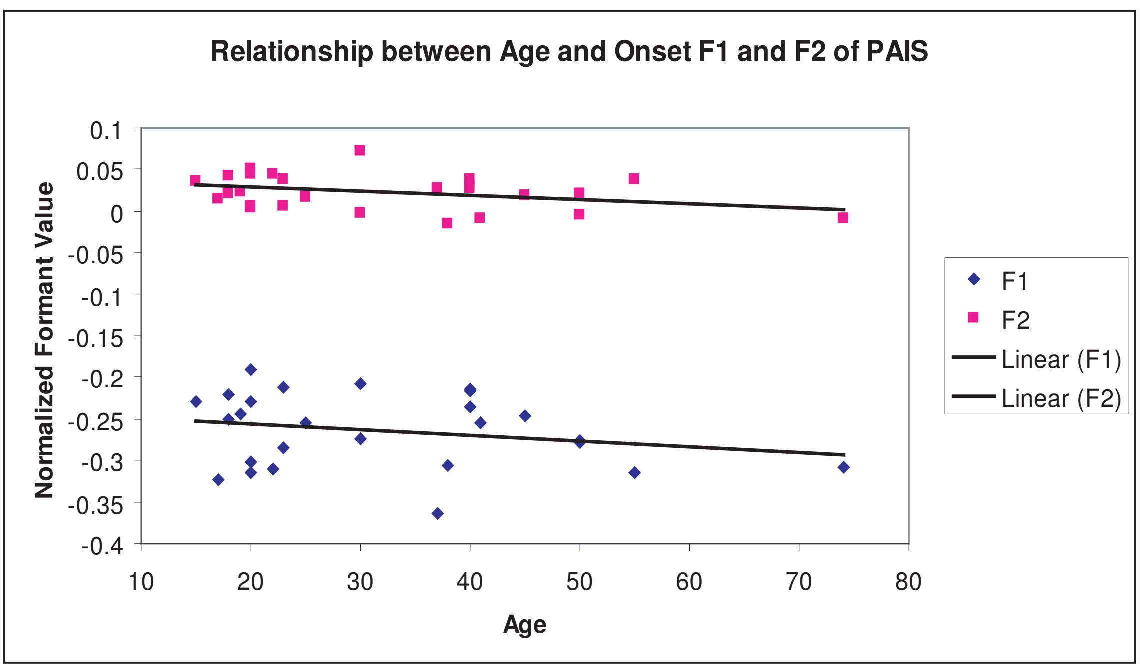


Figure 5.3 : Chart showing the relationship between age and onset F1 and F2 of PAIS.

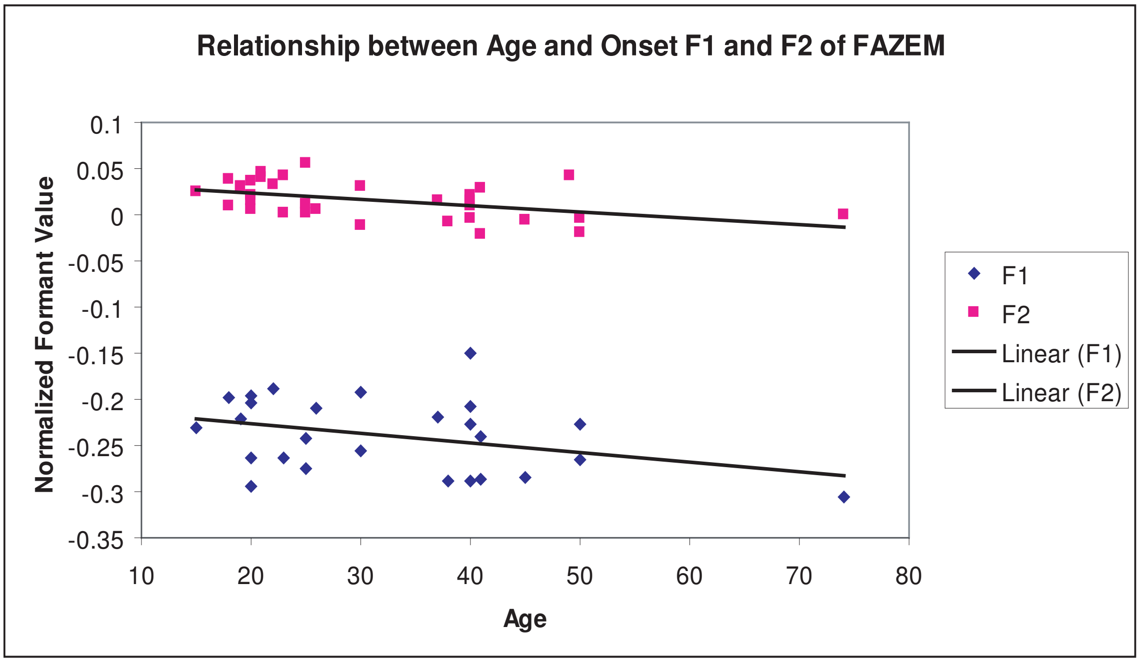
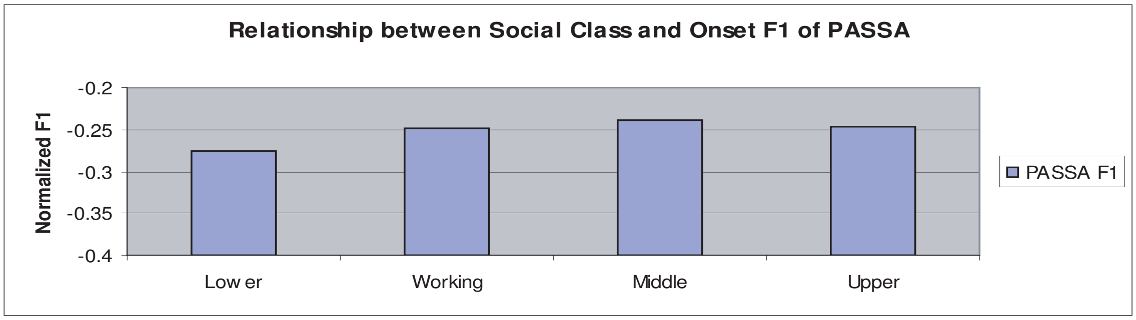


Figure 5.4 : Chart showing the relationship between age and onset F1 and F2 of FAZEM.

pattern for F2 is the same, for MAS, F1 is stable in relation to age, while for MAIS, F1 increases with age. This type of pattern is more likely to be linguistic rather than physiological. The fact that onset formants of MAS and MAIS also correlate with other social variables (sex and class, respectively), while PAIS and FAZEM do not, supports this conclusion, since changes in progress tend to correlate with other social factors besides just age. Although it is not possible to completely rule out age grading as an explanation for this trend, the data do not show the curvilinear pattern typical of age-graded variables. The vowel charts for Rita (page 148) and Liana (page 142) are good examples of the extremes of this continuum. All of Rita's vowels with the exception of PAZ overlap, showing that she has virtually no fronting or raising of her checked vowels. This is, in fact, very unusual, since for most speakers in this study, the checked vowels tend to be at least slightly fronted and/or raised in relation to the open vowels. Speakers with vowel charts similar to Rita's (though showing a small



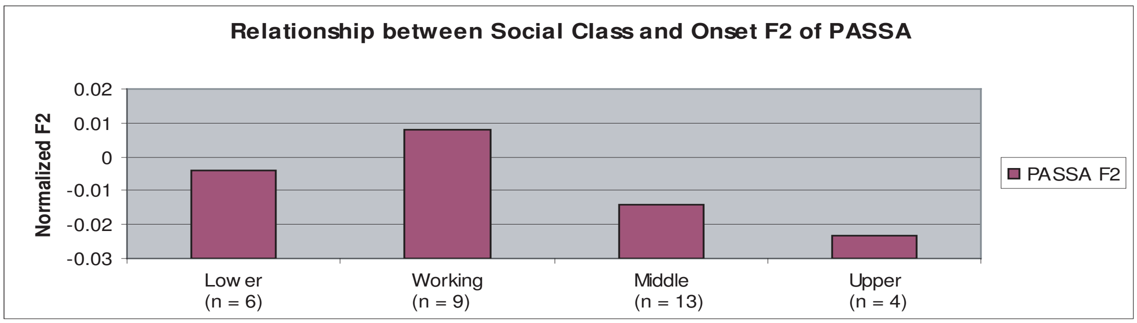


Figure 5.5 : Charts showing the average normalized F1 and F2 of PASSA by social class.

degree of fronting and/or raising of the checked vowels) include Alberto (page 134), Luisa (page 143), and Olívia (page 145). At the other extreme, all of Liana's checked vowels are distinct from open /a/: MAS, MAIS, and PAZ are raised and fronted, while PAIS is only fronted in relation to open /a/. The open vowels themselves are also differentiated, with FAZEM being more fronted than PASSA, a difference that is typical of most speakers. Speakers with vowel charts similar to Liana's include Cláudia (page 137), Susana (page 150), and Taís (page 150).

5.1.1.2 Social Class

The variables PASSA and MAIS both correlate with social class, as shown in ANOVA results in Table 5.1 and in Figures 5.5 and 5.6. For the sake of completeness, F1 is also shown. The F1 of PASSA does not seem to correlate at all with class, though it does in the the case of MAIS (significant at $p = .002$). Figure 5.6 shows that the

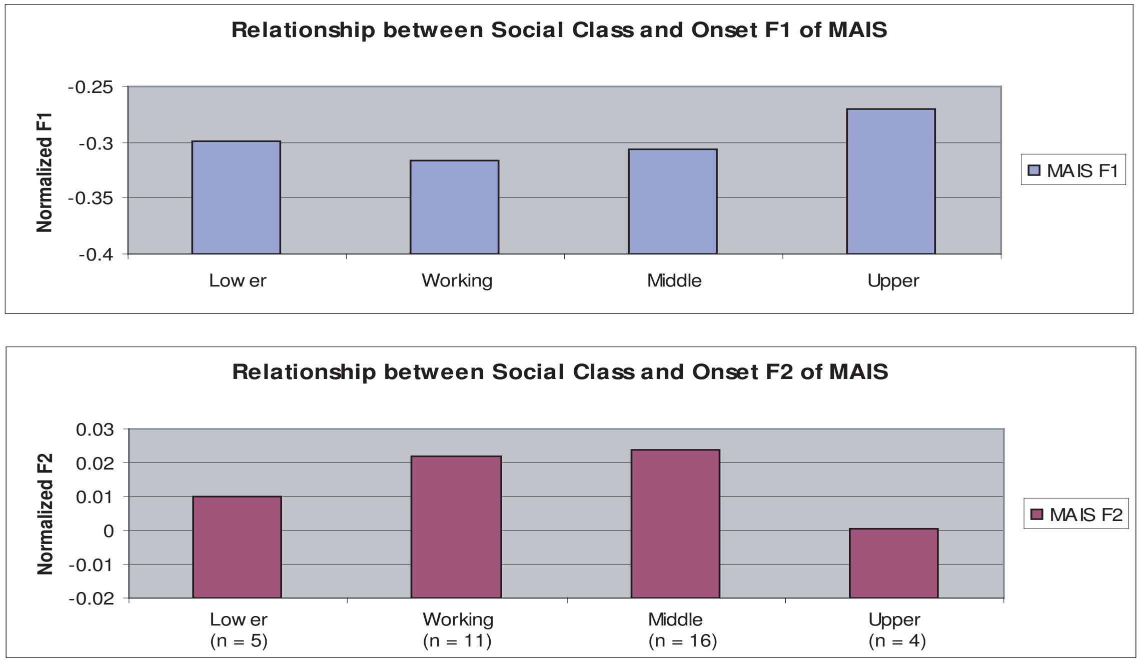


Figure 5.6 : Charts showing the average normalized F1 and F2 of MAIS by social class.

working and middle classes tend to have a lower F1 and a higher F2 for MAIS. Since younger speakers also tend to have a lower F1 and a higher F2 for MAIS, this provides evidence that the central classes are leading the change in the fronting and raising of MAIS. It also suggests that the age correlation found for MAIS in Section 5.1.1.1 is indeed a case of a change in progress, since such changes tend to show a curvilinear distribution with respect to social class (Labov, 2001). Since MAS tends to be ahead of MAIS in terms of fronting and raising, MAIS may be catching up to it for some speakers, and indeed there are cases where the two vowels are both fronted and fully merged. (See, for example, Donato, page 137, who has one of the most fronted examples of MAIS in this study.) However, the F2 of MAS also tends to be higher among younger speakers, and speakers like Liana (page 142) have a fronted MAIS, but a MAS that is even more fronted. These individual differences will be explored further in Chapter 6.

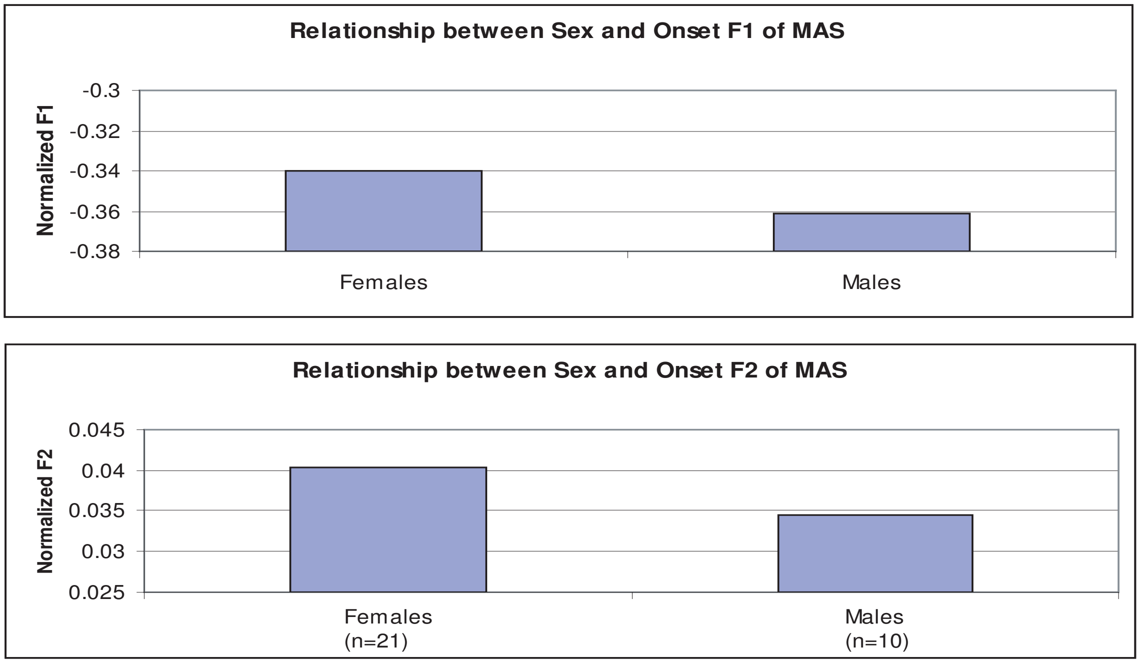


Figure 5.7 : Chart showing the average normalized F1 and F2 of MAS by speaker sex.

The F2 of PASSA shows a similar pattern, except that the working class has the highest average F2, followed by the lower class. The F2 of PASSA also tends to be higher among younger speakers (significant at p = .020). This suggests that the fronting of PASSA may be a newer change originating in the working class, and has not had time to spread to the other classes.

5.1.1.3 Sex

MAS is the only vowel that correlates with speaker sex in Table 5.1. As shown in Figure 5.7, women on average have a higher F2 than men, thus leading the change in the fronting of MAS (cf. Figure 5.1). However, since women tend to have higher formant values than men in general due to differences in the size of the vocal tract, it is necessary to determine if this difference is linguistic and not due to a failure of the the normalization to correct for the physiological difference. One way to test this

is to take the average normalized formant scores for all vowels for men and women.[1] For women the average F2 score is actually lower than the F2 score for men (-.013 for women; .005 for men). This suggests that normalization did indeed correct for the physiological differences between men and women, and the higher F2 for women in the case of MAS is indeed a linguistic difference.

Interestingly, the F2 of MAS does not correlate with social class (p = .463). Generally, when women are the leaders of linguistic changes, they are women of a particular social class (Labov, 2001). Additional data may eventually confirm a relationship with class, but for now there is no evidence for it.

5.1.2 Glides

There are several ways to analyze the glides of vowels, each way revealing a different aspect of the glide. The F1 and F2 of the offset provide information on the target of the glide. The Cartesian distance between the onset and the offset is a indication of how diphthongal the vowel is. However, this measure of diphthongization cannot accurately be interpreted without also examining the steady state properties of the vowel's formants. The two spectrograms of /a/ in *mas* "but" and *casa* "house" in Figure 5.8 illustrate this point.

These two tokens do not differ much in terms of Cartesian distance: 487 Hz for *casa* and 476 Hz for *mas*. What distinguishes these tokens is when the formants begin to change. Using the method for calculating the start of formant change given in Section 3.1, the start of formant change is 64% for *casa* and 0% for *mas* in these examples. In other words, the formants in *casa* have a steady state in the middle

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[1] This average is actually average of averages—that is, the average of each vowel's average F2 score for men and women. Thus the fact some speakers have differing numbers of tokens for each vowel does not affect the average.

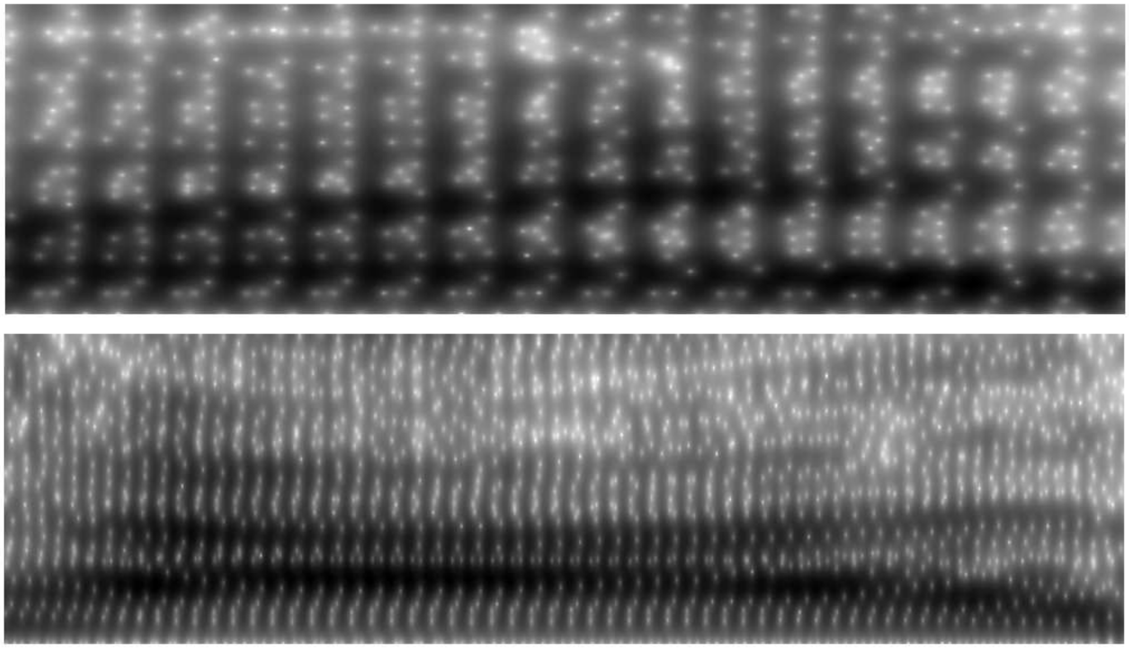


Figure 5.8 : Spectrograms of /a/ in *mas* (top, spoken by Laura) and *casa* (bottom, spoken by Paula)

portion of the vowel and begin to move toward their target about two-thirds of the way through the vowel; in *mas*, there is no steady state, as the formants begin to move toward their target immediately from the start of the vowel. Thus, this token of *mas* is very diphthongal; the formants change throughout the duration of the vowel. *Casa*, however, is more monophthongal in comparison. Although the formants change about the same amount as those of *mas* in terms of Cartesian distance, the change occurs toward the end of the vowel, suggesting that the formant movement is due more to coarticulartion with the following consonant than diphthongization. These examples not only illustrate the importance of considering both the Cartesian distance and the steady state patterns, they also suggest that diphthongization and coarticulation are related. The examples given represent two extremes of a continuum. The starting points of formant change in this study range from any point starting at 0% and approaching 100% (100% itself represents little or no formant change). This idea is

Source	Dependent Variable	F	Sig.
Age	MAS Offset F1	6.206	.023
	PASSA Offset F2	13.950	.002
	PASSA Cart. Dist.	10.996	.004
	PASSA Formant Change	10.234	.005
	FAZEM Offset F1	6.807	.018
	FAZEM Offset F2	11.568	.003
	FAZEM Cart. Dist.	25.968	.000
	FAZEM Formant Change	11.195	.004
Class	MAIS Cart. Dist.	5.154	.036
	PASSA Offset F2	7.568	.014
	PASSA Cart. Dist.	4.891	.041
	FAZEM Cart. Dist.	7.885	.012
Sex	PASSA Cart. Dist.	10.020	.006
	FAZEM Cart. Dist.	6.365	.022

Table 5.2 : ANOVA results showing significant correlations between vowel glides (offset F1 and F2, Cartesian distance between the onset and offset, start of formant change) and social variables (age, class, sex)

explored further in Section 5.3.

Table 5.2 shows the results from the ANOVA test that relate to glides. Only those significant at $\alpha = 0.05$ are shown.

5.1.2.1 Age

The glide data for PASSA and FAZEM both correlate with age, showing increasing diphthongization among younger speakers. This result is unexpected since neither PASSA nor FAZEM have been noted to be diphthongized in Portuguese. Figures 5.9

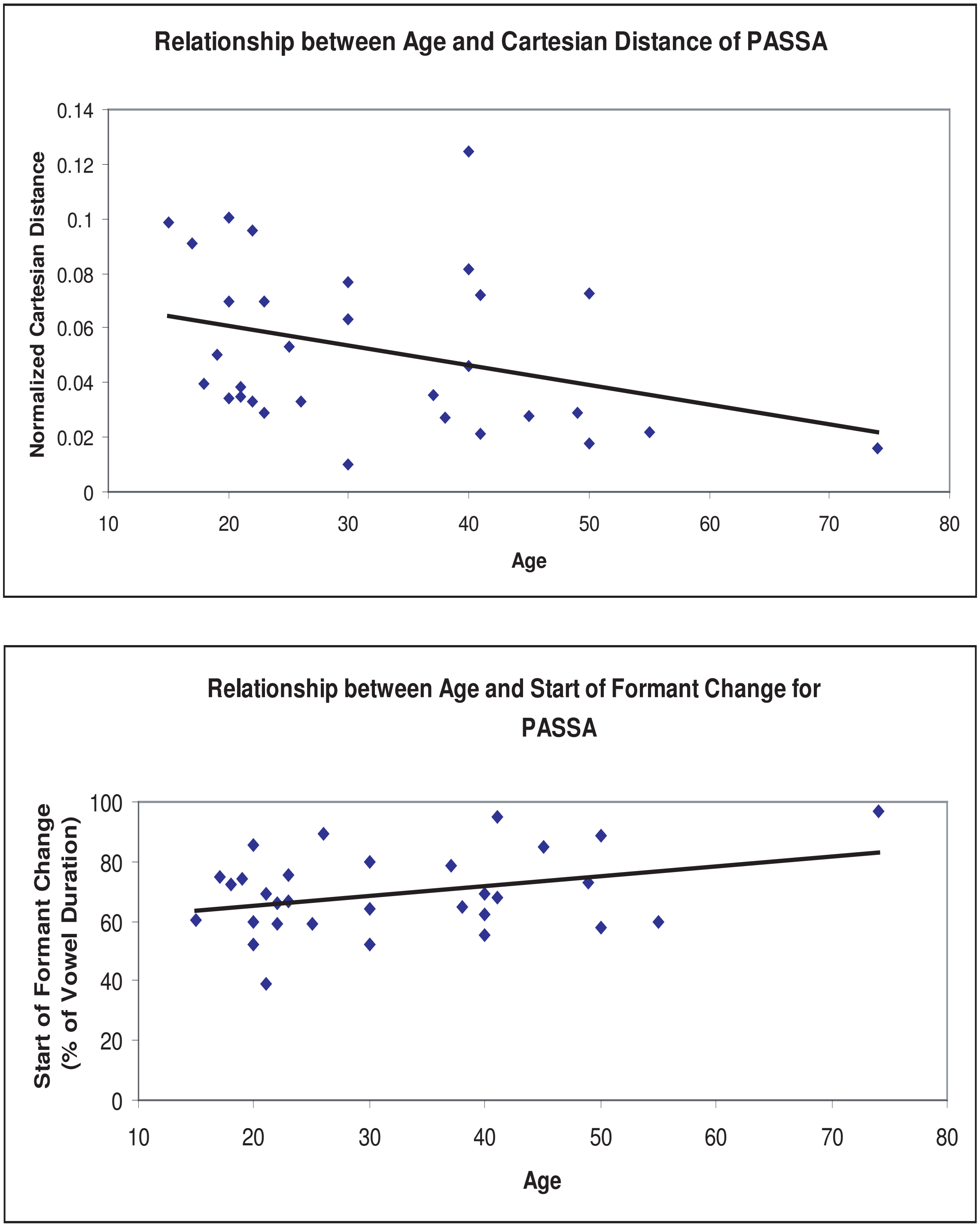


Figure 5.9 : Charts showing the relationship between age and the Cartesian distance and the start of formant change of the PASSA glide.

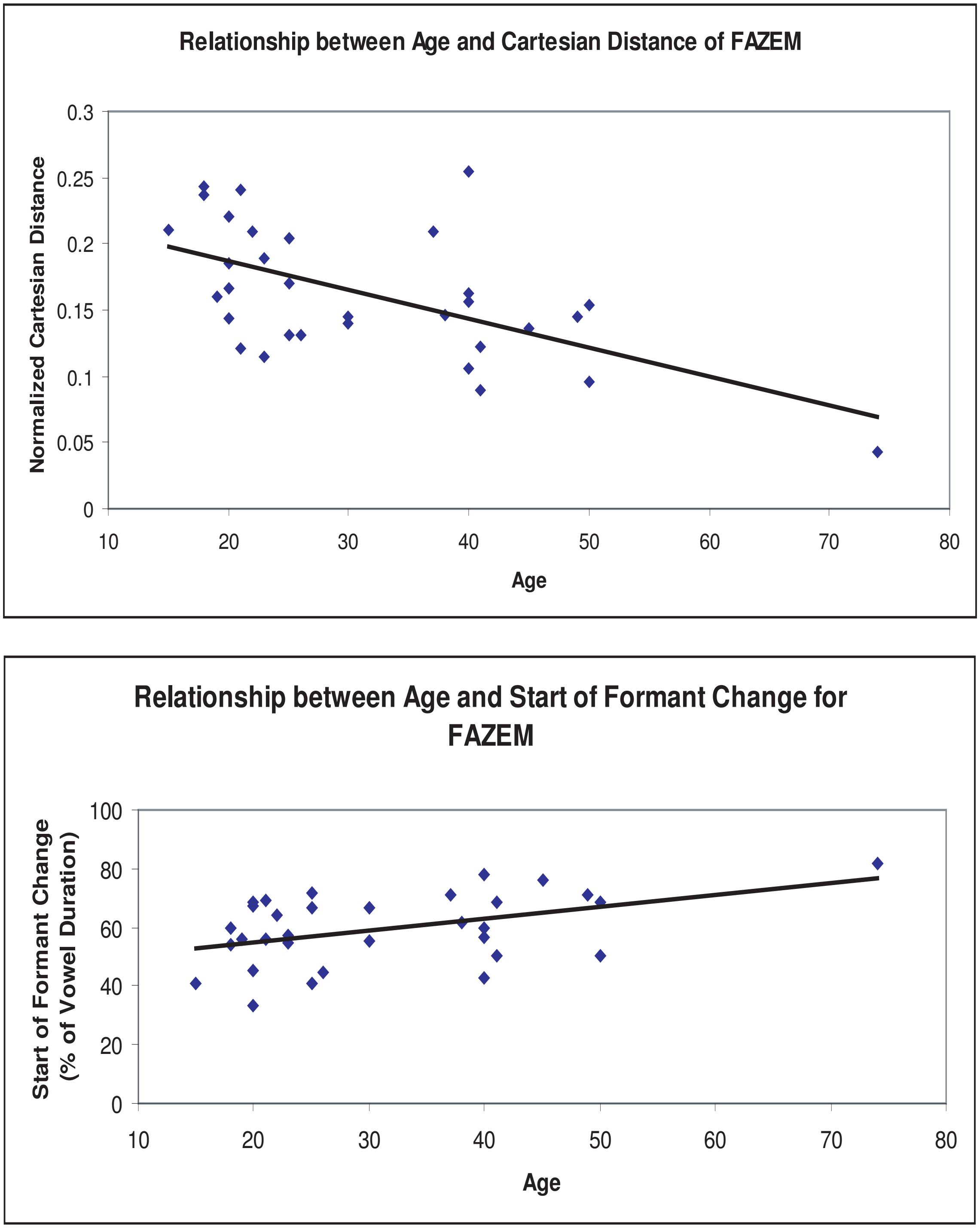


Figure 5.10 : Charts showing the relationship between age and the Cartesian distance and the start of formant change of the FAZEM glide.

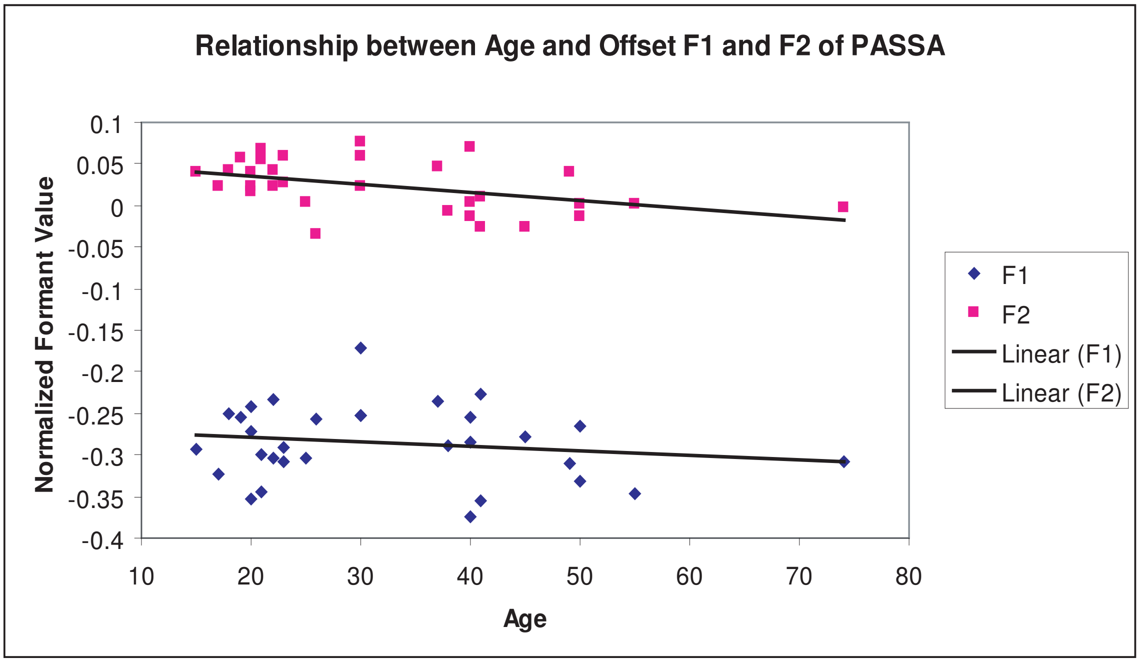


Figure 5.11 : Chart showing the relationship between age the offset F1 and F2 of PASSA.

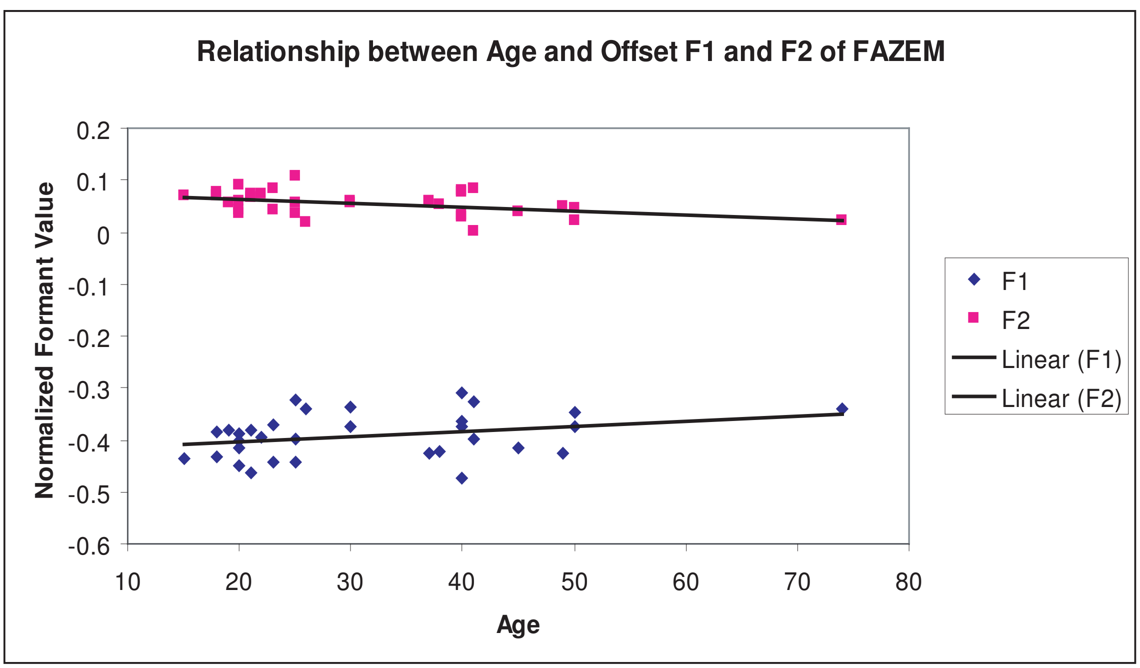


Figure 5.12 : Chart showing the relationship between age the offset F1 and F2 of FAZEM.

and 5.10 show that the Cartesian distance between the onset and offset tends to be higher among younger speakers. At the same time, the start of formant change tends to occur sooner in the vowel for younger speakers. The glide targets of both vowels also tend to be more fronted for younger speakers, and in the case of FAZEM, higher as well. Figure 5.12 shows that younger speakers tend to have a lower F1 and a higher F2 for the offset of FAZEM, while Figure 5.11 shows that younger speakers tend to have a higher F2 for PASSA. Taken together, these findings provide strong evidence that open /a/ is becoming more diphthongal. The increase in Cartesian distance indicates that the glide targets are moving further from the onset, and the relationship between age and the offset formants confirms this. In addition, the average start of formant change occurs sooner in the vowel for younger speakers. While open /a/ is not yet fully diphthongal, these results likely show the early signs of diphthongization.

Checked /a/, on the other hand, is already as diphthongal as checked /ai/ for most speakers. Open /a/ is still more monophthongal for all speakers: there are no cases where the glide of open /a/ appears to be merging with that of checked /a/ or /ai/. Nonetheless, they do tend to have glides going in the same direction as checked /a/, particularly in the case of FAZEM. Bruna, who has the most diphthongal FAZEM vowel in this study in terms of Cartesian distance (see chart on page 135), provides a good example. All of her glides go in the direction of [i]. There is little difference in the targets of MAS, MAIS, PAZ, and PAIS—all of them are fully diphthongized to [ai]. The average glide offset of FAZEM is about 50-150 Hz lower and about 350-400 Hz more backed than the glides of checked /a/. The average PASSA offset is less than 100 Hz lower and more backed than the FAZEM offset. The FAZEM offset is always higher and more fronted than the PASSA offset in this study, except for Humberto (page 139) and Lucas (page 142), where it is only higher. For some speakers, the FAZEM offset is almost as high as those for checked /a/, but still not as fronted

(eg. Salina, page 149; Taís, page 150). Many speakers show no appreciable glide for PASSA (Geraldo, page 138; Rita, page 148; Tiago, page 151).

The open /a/ glide also remains distinct from checked /a/ in terms of the start of formant change for most speakers. For Bruna, for example, the average start of formant change for open /a/ is 57% of the vowel duration, compared to 17% for checked /a/ and 12% for checked /ai/. The only speaker for whom the starting point of the open /a/ approaches that of checked /a/ is Liana. For her, the average start of formant change is 39% for open /a/, 31% for checked /a/, and 12% for checked /ai/. Even the average Cartesian distance of her glides are similar: 287 Hz for open /a/, 305 Hz for checked /a/, and 420 Hz for checked /ai/. Her vowel chart (page 142), however, reveals that her open and checked /a/ remain distinct. Both the onsets and the offsets of PAZ and MAS are more fronted than FAZEM and PASSA. In addition, the glides tend to go in different directions. The FAZEM glide in particular moves more in the F1 demension than the F2 demension. The closeness in the values for Cartesian distance between open /a/ and checked /a/ for Liana are likely due to two different factors. For open /a/, the Cartesian distance is higher than usual because of the raising of the glide target. For checked /a/, the Cartesian distance is lower than usual because the onset of the vowel is fronted and raised, thus making the distance to the target offset shorter.

The case of Liana is interesting in that it shows that a vowel can become diphthongized in more than one way, since presumably open and checked /a/ were historically the same vowel. In the checked environment, /a/ developed a glide approaching [i] and its onset became fronted and raised. In the open environment, the glide approaches [ə] and the onset is lower and further back. It also shows that vowels can have similar glide patterns in terms of Cartesian distance and the start of formant change, yet still remain distinct. For most speakers, though, the start of formant change and the glide

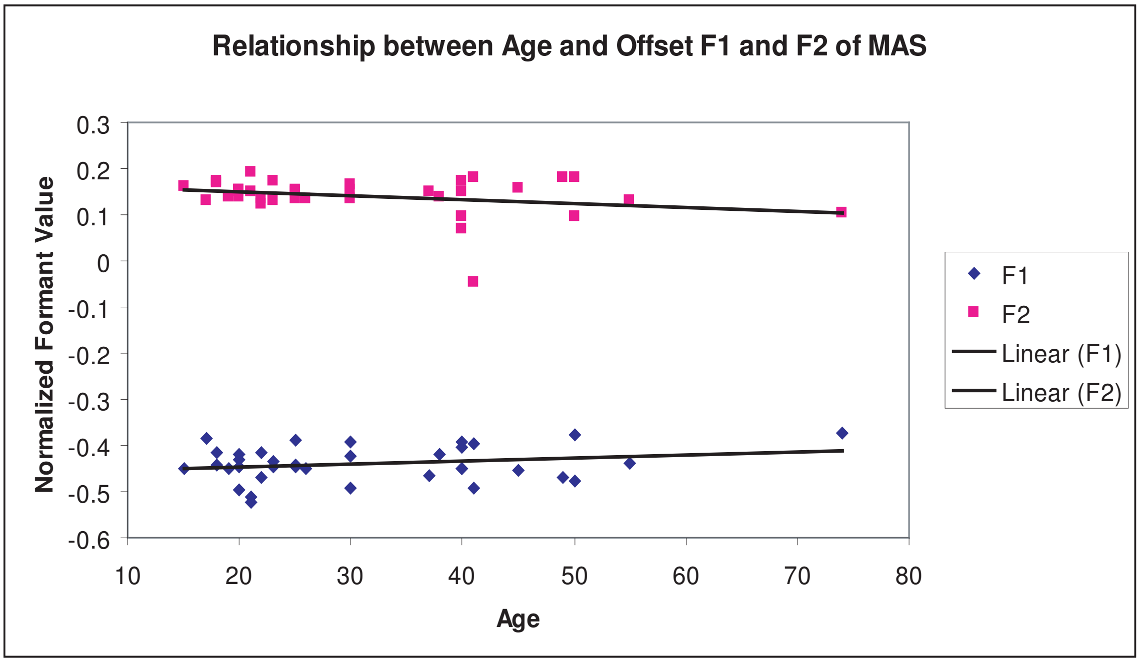
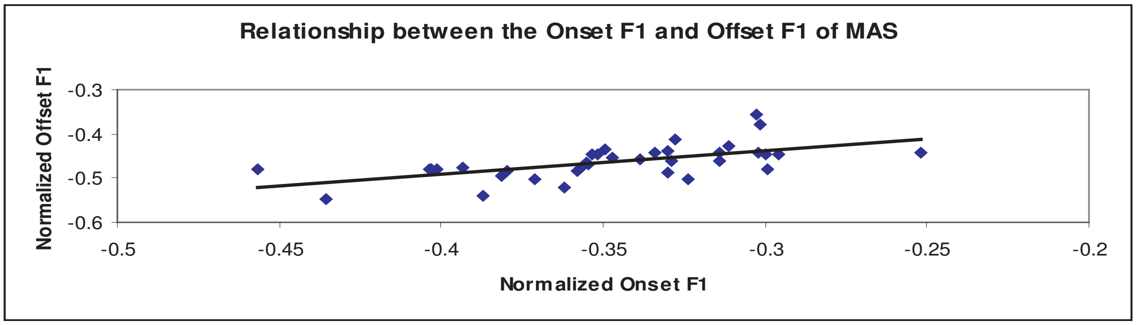


Figure 5.13 : Chart showing the relationship between age and the offset F1 and F2 of MAS.

targets of these vowels follow similar but distinct patterns. Checked /a/ and /ai/ have glides that approach [i] and start well before the midpoint of the vowel. Open /a/ glides go in the same direction, but do not reach [i], and usually start after the midpoint of the vowel. It is impossible to determine whether this increased amount of diphthongization will ever approach the current level of diphthongization of checked /a/. Although it may be heading in that direction, as with all sound changes, there is no way of predicting how far it will go.

The offset F1 of MAS also correlates with age, again with younger speakers tending to have higher glide targets, as shown in Figure 5.13. The fact that neither the Cartesian distance nor the start of formant change correlates with age suggests that, unlike PASSA and FAZEM, this is not a case of the vowel becoming more diphthongal. In this case, the raising of the glide target may be related to the raising of the onset. Figure 5.14 shows that this is indeed the case. These charts show the relationship



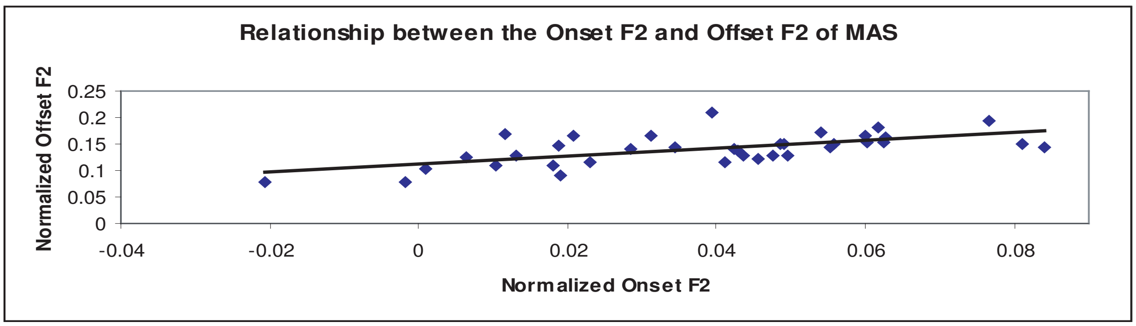


Figure 5.14 : Charts showing the relationship between the onset formants and the offset formants of MAS.

between the onset formants and the offset formants. For both F1 and F2, as the onset formants increase, the offset formants also increase. This suggests that as diphthongs move in the vowel space, both the onset and glide are affected. At first, this information might seem to contradict the claim made earlier in this section that the Cartesian distance of Liana's MAS glide is shorter because her MAS is fronted and raised. However, the slope of the lines show that there is no contradiction. The slope of the trend lines in Figure 5.14 are 0.53 for F1 and 0.73 for F2. In other words, for every 1 unit of increase of the onset, the offset increases by about a half a unit for F1 and about three-quarters of a unit for F2. Thus even though movements of the onset and offset in the vowel space are related, the fronting and raising of the offset does not keep up with the fronting and raising of the onset. This is likely due to the fact that as the offset approaches [i], any additional fronting and raising is limited by the boundaries of the vowel space.

5.1.2.2 Social Class

Figure 5.15 shows the relationship between social class and the three glide variables of PASSA. The ANOVA (Table 5.2) shows that the relationship with offset F2 and Cartesian distance are significant ($p = .014$ and $p = .041$, respectively), while the relationship with the start of formant change is nearly significant ($p = .056$). Section 5.1.2.1 showed that all three of these correlated with age, with the offset F2 becoming more fronted, the Cartesian distance increasing, and the start of formant change occurring sooner in the vowel among younger speakers. All three of these indicate the direction of change: that PASSA is becoming increasingly diphthongal. Two of the three variables indicate that the working class is leading this change. In terms of the glide target, the working class has the highest offset F2, while the start of formant change tends to occur sooner for the lower and working class than the middle and upper classes. The data for Cartesian distance is less clear. In this case the lower and upper classes have the highest Cartesian distance. The fact that the working classes has the highest onset F2 and highest offset F2 for PASSA suggests that in addition to becoming increasingly diphthongal, PASSA is also becoming increasingly fronted. The data suggests that the working class may be leading the change in the fronting of PASSA, since they have the highest average F2 for both the onset and offset. The lower class, on the other hand, may be leading the change in diphthongization, since they have both a high value for Cartesian distance and a relatively low value for the start of formant change. With data from only five lower class speakers, however, this idea is tentative until more data can be collected.

In all cases, it seems clear that the middle class is the least affected by these changes. They have the lowest offset F2, the lowest value for Cartesian distance, and the highest value for the start of formant change. The results for the upper class remain less clear, perhaps again due to a lack of data, with only four speakers.

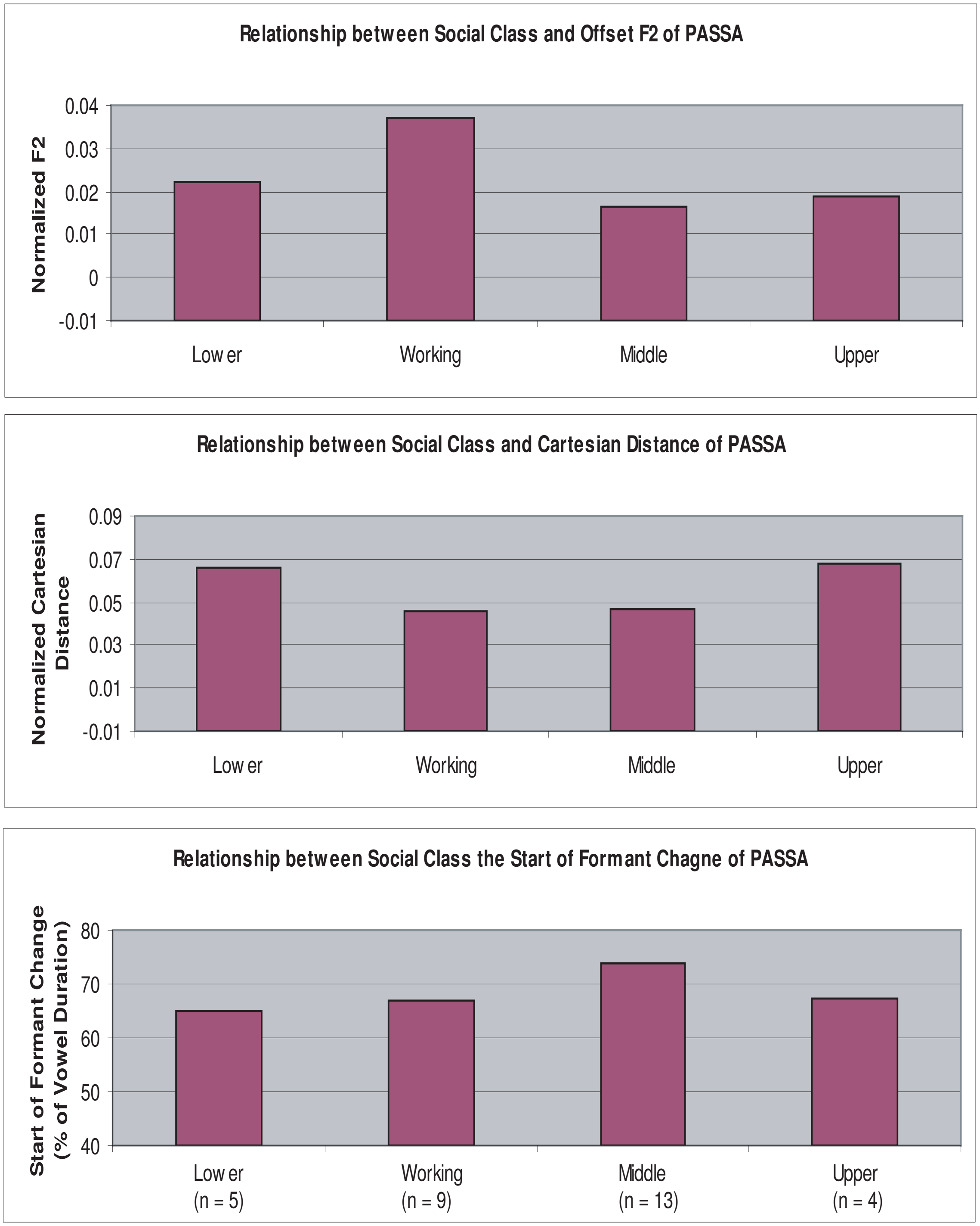


Figure 5.15 : Charts showing the relationship between social class and the offset F2, Cartesian distance, and start of formant change for PASSA

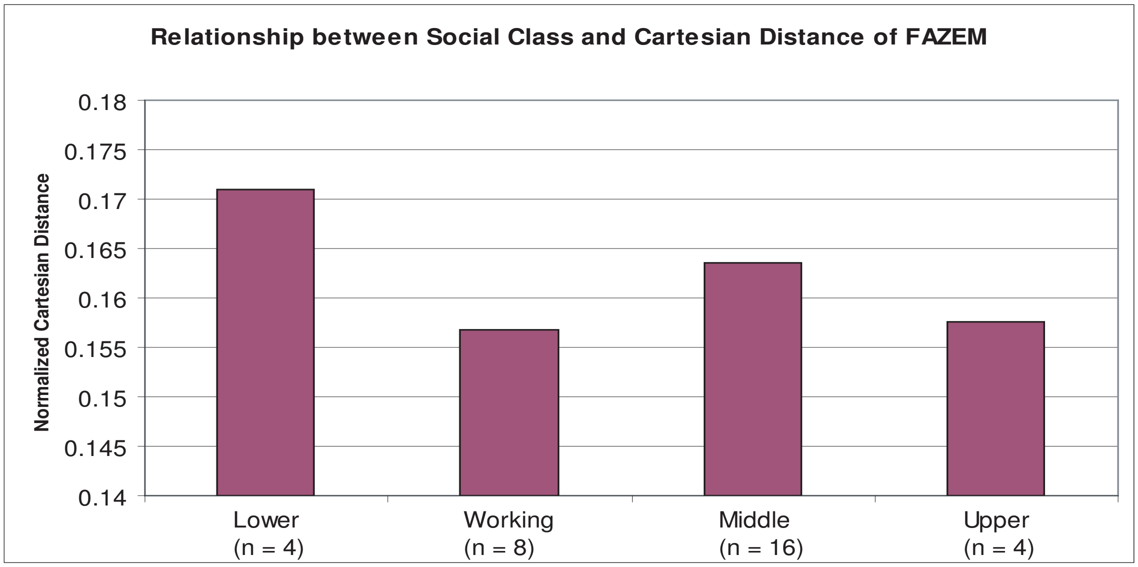
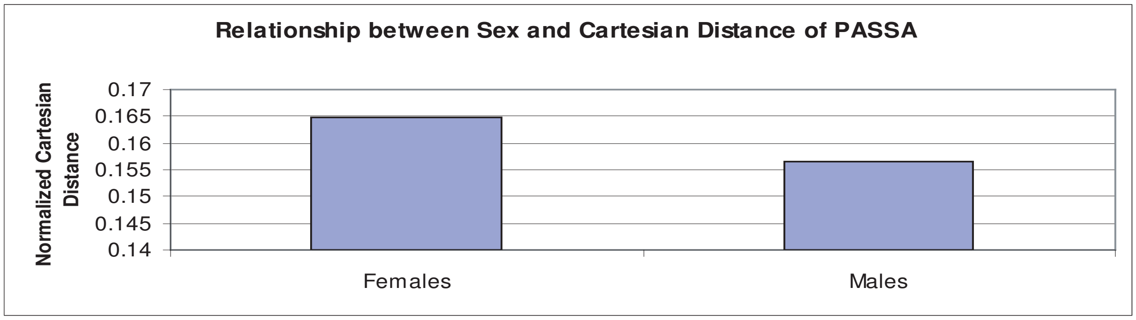


Figure 5.16 : Chart showing the relationship between social class and the Cartesian Distance of FAZEM.

Although FAZEM also appears to be becoming increasingly diphthongal, only the Cartesian distance correlates with social class. As with PASSA, the lower class has higher Cartesian distance scores than the working and middle classes. The Cartesian distance of FAZEM is higher than that of PASSA for all speakers, which suggests that FAZEM is more advanced than PASSA in terms of diphthongization. Comparing the start of formant change confirms that this trend is generally true: for most speakers, the start of formant change is sooner for FAZEM than PASSA. Interestingly, most of the exceptions (5 out of 7) are in the lower and working classes. This is likely due to the fact that the lower and working classes tend to show signs of diphthongization for both FAZEM and PASSA, while for most speakers in the other classes only FAZEM shows signs of diphthongization. This may indicate why the start of formant change for FAZEM did not correlate with class ($p = .459$). The diphthongization of FAZEM may be an older, more established change than PASSA, thus it has had time to spread to all of the classes.



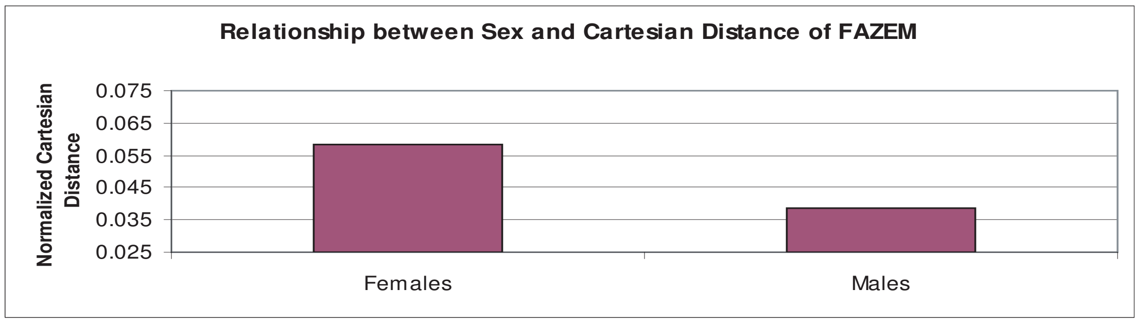


Figure 5.17 : Charts showing the relationship between speaker sex and the Cartesian Distance of PASSA and FAZEM.

5.1.2.3 Sex

The Cartesian distance of PASSA and FAZEM also correlates with speaker sex, with women having a higher average Cartesian distance than men in both cases, as shown in Figure 5.17. Although the high value for the Cartesian distance of PASSA for the upper class is an anomaly, the data otherwise shows a clear picture: increased Cartesian distance for open /a/ is favored by young, lower class females. This pattern is common for linguistic changes in progress that originate in one of the lower classes.

5.1.3 Duration

The vowels analyzed in the previous sections also vary by average duration. These differences help explain the direction of change that these vowels are moving in the vowel space. For most speakers, FAZEM is longer than PASSA, PAZ is longer than MAS, and PAIS is longer than MAIS. (The only exceptions are Liana for FAZEM

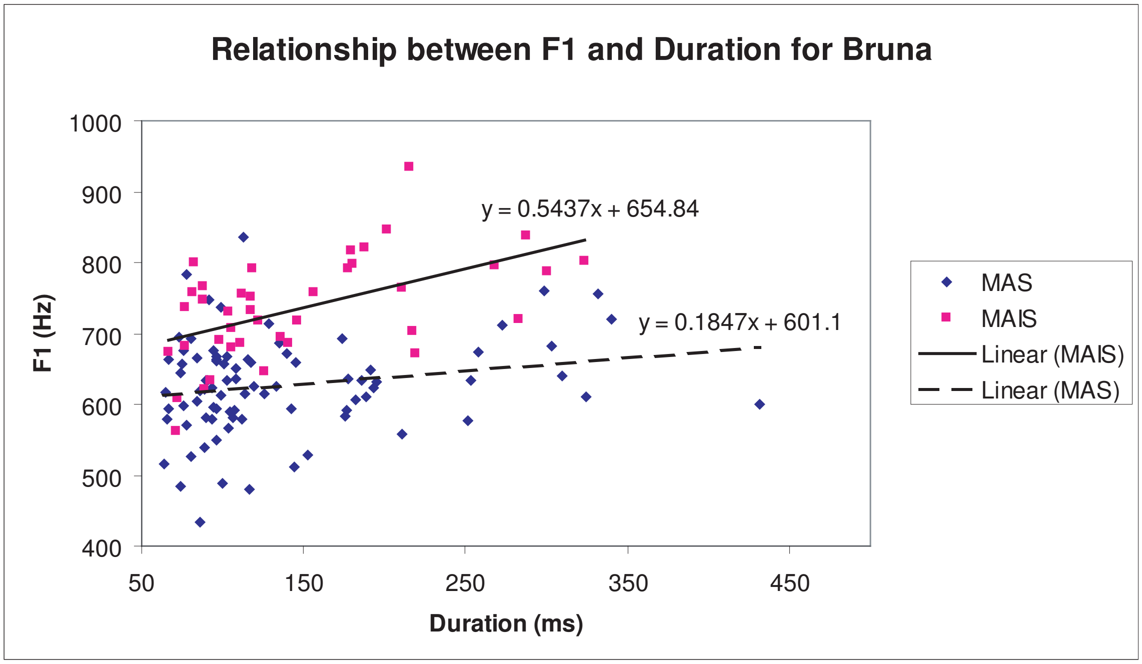


Figure 5.18 : Chart showing the relationship between F1 and duration of MAS and MAIS for Bruna.

vs. PASSA and Taís, Donato, and Pedro for PAZ vs. MAS.) The case of FAZEM and PASSA can be explained by the fact that vowels tend to be longer before voiced consonants than voiceless ones (Ladefoged, 2001). The other two differences can be explained by the fact that MAS and MAIS, as noted at the beginning of this chapter, are function words and thus tend to be reduced.

Figures 5.18 and 5.19 show the relationship between duration and the F1 and F2 of MAS and MAIS for Bruna. As the duration of these vowels increases, F1 increases and F2 decreases. Thus the shorter tokens of MAS and MAIS are the ones that are most likely to be fronted and raised. Thomas (1995) found the same correlation with the fronting of /ai/ in Ohioan English. He attributes this to undershoot, the coarticulation between the onset and offset of the glide. At shorter durations, the onset becomes closer to the glide, resulting in fronting and/or raising of the onset in the case of /ai/ diphthongs.

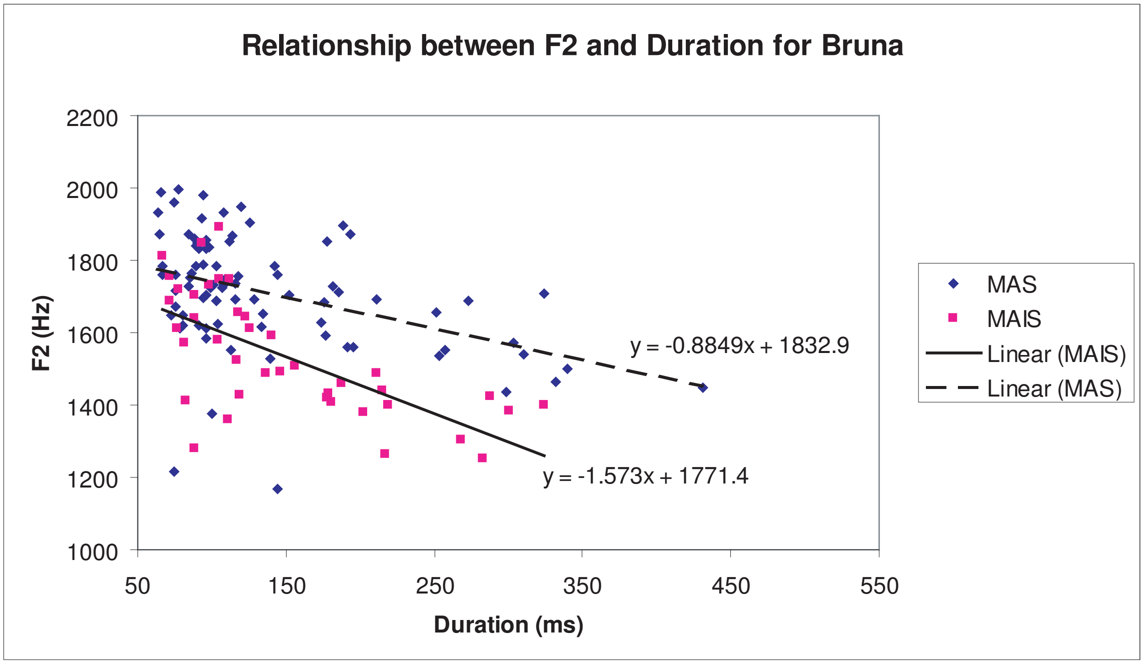


Figure 5.19 : Chart showing the relationship between F2 and duration of MAS and MAIS for Bruna.

In the case of Bruna, the distinction between MAS and MAIS is not merely a consequence of MAS being shorter and therefore more susceptible to fronting and raising. As shown in Figures 5.18 and 5.19, MAS and MAIS are even more distinct at longer durations than shorter durations, since MAIS has a more positive slope for F1 (0.54 for MAIS vs. 0.18 for MAS) and a more negative slope for F2 (-1.57 for MAIS vs. -0.88 for MAS). In addition, MAIS has a slightly higher y-intercept for for F1 (655 for MAIS vs. 601 for MAS) and a lower y-intercept for F2 (1771 for MAIS vs. 1833 for MAS).

Few participants show the same distinction between MAS and MAIS as Bruna, however, with the two vowels becoming more distinct at longer durations. Only Cláudia shows the same pattern, and to a lesser extent, José for F2. More typical are cases like Vitória, as shown in Figures 5.20 and 5.21. In this case, the distinction between MAS and MAIS is greater at shorter durations, suggesting that the difference

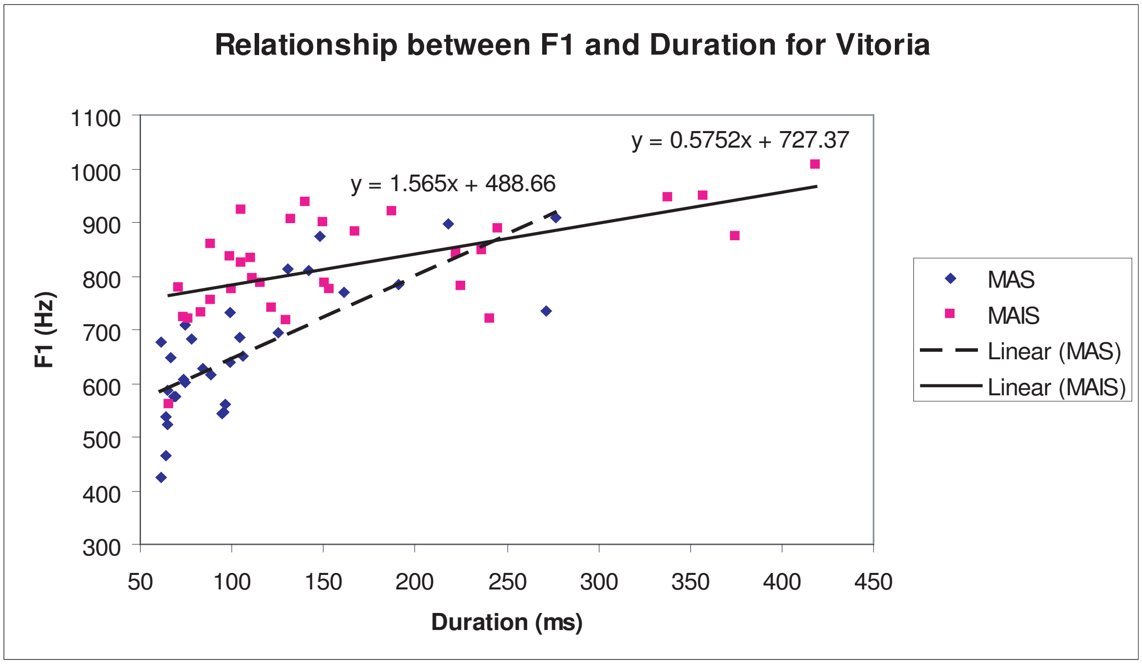


Figure 5.20 : Chart showing the relationship between F1 and duration of MAS and MAIS for Vitória.

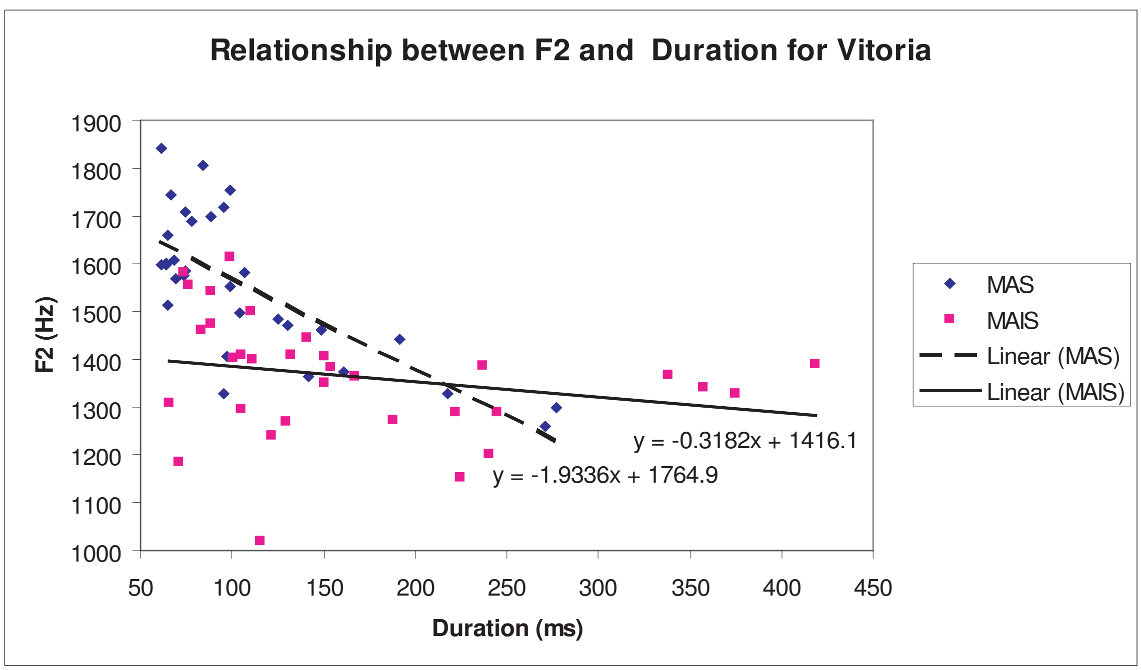


Figure 5.21 : Chart showing the relationship between F2 and duration of MAS and MAIS for Vitória.

is mostly due to the reduction of MAS. This difference is not reflected in the vowel charts, which show average F1 and F2 values over all durations. Thus for both Bruna (page 135) and Vitória (page 151), MAS and MAIS appear to be quite distinct according to their vowel charts, but these charts do not show how the duration of the vowels relates to the formant values.

Thomas (1995) argues that the slope of the regression lines on the F2-Duration plots are closely related to the degree of fronting of F2: the higher the slope, the higher the F2 value, based on his data for /ai/ fronting in Ohio. This same correlation was found for MAS and MAIS in this study, but not for PAZ and PAIS. Correlating the slope of each participants' regression line (for F2 vs. duration) with their normalized F2 values yields R^2 values of 0.152 for MAS, 0.135 for MAIS, 0.002 for PAZ, and 0.008 for PAIS. Only the correlations with MAS and MAIS are significant, according to separate one-way ANOVAs (MAS: F = 6.099, p = 0.019; MAIS: F = 5.311, p = 0.027).

These results make since given that MAS and MAIS tend to be the most fronted vowels in this study and also among the shortest vowels. The frequent reduction of the function words MAS and MAIS may have provided the initial phonetic motivation for fronting: the shorter the duration of the diphthong, the stronger the coarticulation between the onset and the offset. This causes the onset to move closer to the offset, resulting in a shorter glide and an onset closer to [i]. Reduction of the other vowels does not appear to be the main cause of their fronting, given the lack of correlation between participants with high F2 scores and strong slopes for the F2-Duration regression. Instead, they could have become fronted by analogy with MAS and MAIS. It's important to keep in mind that MAS and PAZ are the same vowel in the same phonetic environment, as are MAIS and PAIS. The only reason the words *mas* and *mais* where analyzed separately was because they are more likely to be reduced and

potentially show different patterns of diphthongization than other words of this type.

5.2 Back Vowels

The data for the back vowels /ɔ/, /o/, and /oi/ in the pre-/S/ environment is reduced, since not all speakers produced sufficient tokens of these vowels for analysis. The data in this section is based on 15 of the 36 total speakers in this study, though not all of these speakers produced tokens of all three vowels.

In many ways, the patterns found for /a/ parallel those for the pre-/S/ back vowels. Checked /ɔ/ and /o/ are as diphthongal or even more diphthongal than the canonical diphthong /oi/. The open vowels are more monophthongal, but also show signs of diphthongization. Fronting of the onsets of checked /ɔ/ and /oi/ is common, but interestingly checked /o/ remains back for most speakers in this study.

There are also many ways in which the back vowels differ from /a/. Unlike the case of checked /a/ and /ai/, which are either merged or in very close proximity, the merger of checked /o/ and /oi/ is less common. Although both vowels are fully diphthongal, /oi/ is generally more fronted than /o/. In fact, for one speaker in this study (Fabiana, page 138), /oi/ is distinct from /o/ but in close proximity to /ɔ/. Most speakers, however, have at least three distinct mid-back upgliding diphthongs, with checked /ɔ/, /o/, and /oi/ realized as something close to [ɔi], [oi] and [ɵi]. (Since words like "faróis" /farɔis/ did not occur in the data, it is not known how the /ɔi/ diphthong fits into this system.) There are no minimal pairs involving /o/, however; in fact, there is only one frequently occurring word with /o/ in this environment, *arroz* "rice" (though there are a few infrequent words, such as *algoz* "executioner.")

An ANOVA test for the back vowels, set up identically to the one for /a/, did not reveal any significant correlations for class or sex. This may be because the reduced amount of data is simply unable to reveal any correlations. Two correlations were

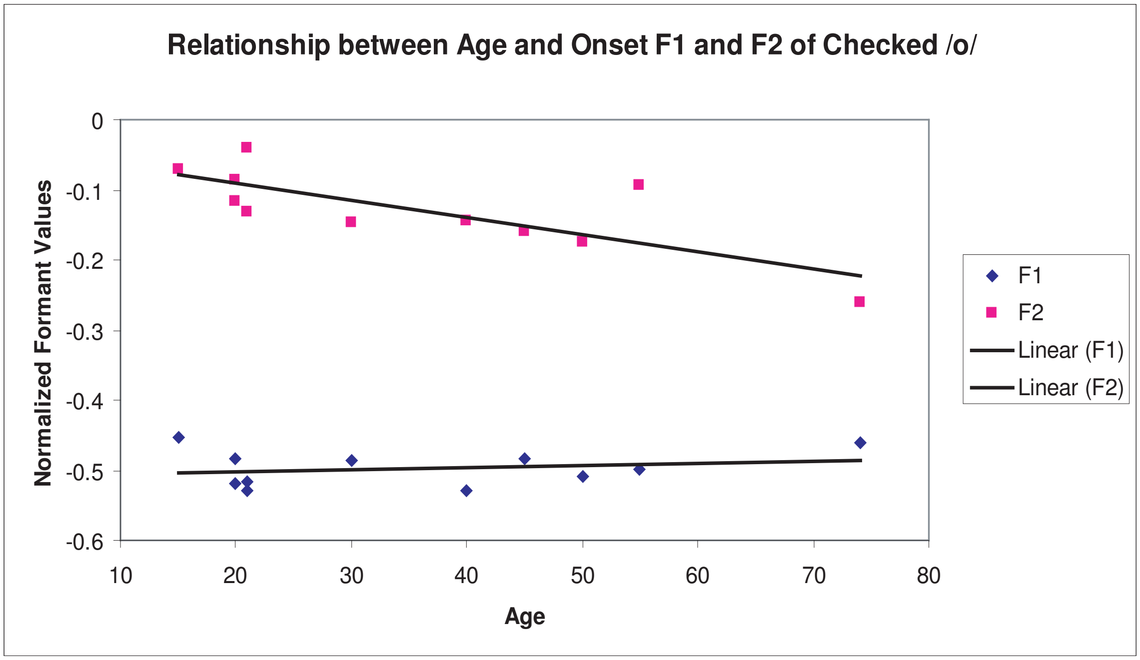


Figure 5.22 : Chart showing the relationship between age and the onset F1 and F2 of checked /o/.

found with age, however: the onset F2 of checked /o/ (F = 36.622, p = .003) and the offset F1 of checked /ɔ/ (F = 9.720, p = .036).

Figure 5.22 shows that younger speakers tend to have a higher F2 than older speakers for checked /o/, while F1 is more stable across all age groups. Since checked /o/ is the most backed of all three back vowels for all speakers in this study, this may indicate the beginning of a change for checked /o/. While checked /ɔ/ and /oi/ are already fronted, checked /o/ has only begun to show signs of fronting among younger speakers. José (page 140), a 21 year old working-class speaker, has by far the highest average F2 score for checked /o/, nearly 1.5 standard deviations above the mean (mean normalized F2 score: -.130 with SD of .059; José's F2 score: -.041). Although more data is needed to confirm this trend, this may be an indication that the working class is again leading this change. (Only one other working class participant, Priscila [page 147], has data for checked /o/; her F2 score of -.131 is nearly identical to the

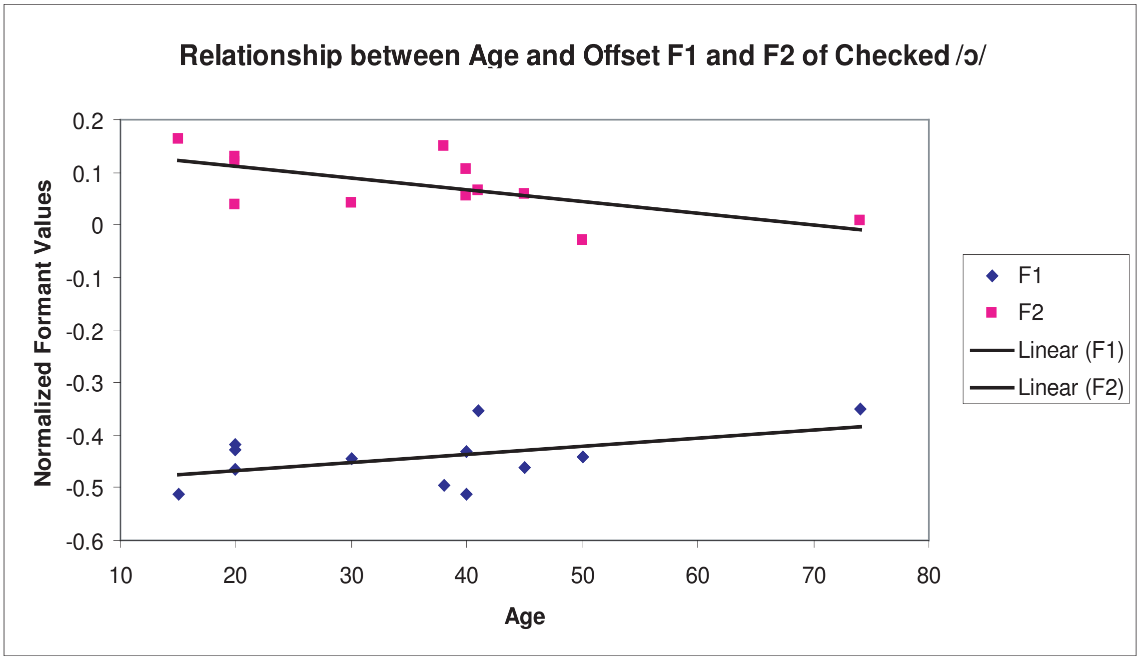


Figure 5.23 : Chart showing the relationship between age and the offset F1 and F2 of checked /ɔ/.

mean score.) The youngest speaker in the sample, Salina (page 149), a 15 year old upper-class speaker, is the only speaker for whom checked /o/ is nearly as fronted as checked /oi/; in fact, the two appear to be merged based on her vowel chart. This may be partly due to the fact that her /oi/ is less fronted than most other speakers. Her mother, Helena (page 139), shows a similar pattern, and these two vowels may be merged or nearly merged for her as well. Both checked /o/ and /oi/ are more fronted for Salina than Helena, suggesting that she may have developed this merged system from her mother and taken it a step further by fronting both vowels.

Figure 5.23 shows that younger speakers tend to have a lower F1 and a higher F2 for the offset of checked /ɔ/, although only the correlation for F1 is significant. This may indicate that either checked /ɔ/ is becoming increasingly raised or increasingly diphthongal, depending on whether or not the onset is stable with regard to age. Figure 5.24 shows the relationship between age and the onsets of checked /ɔ/. F2

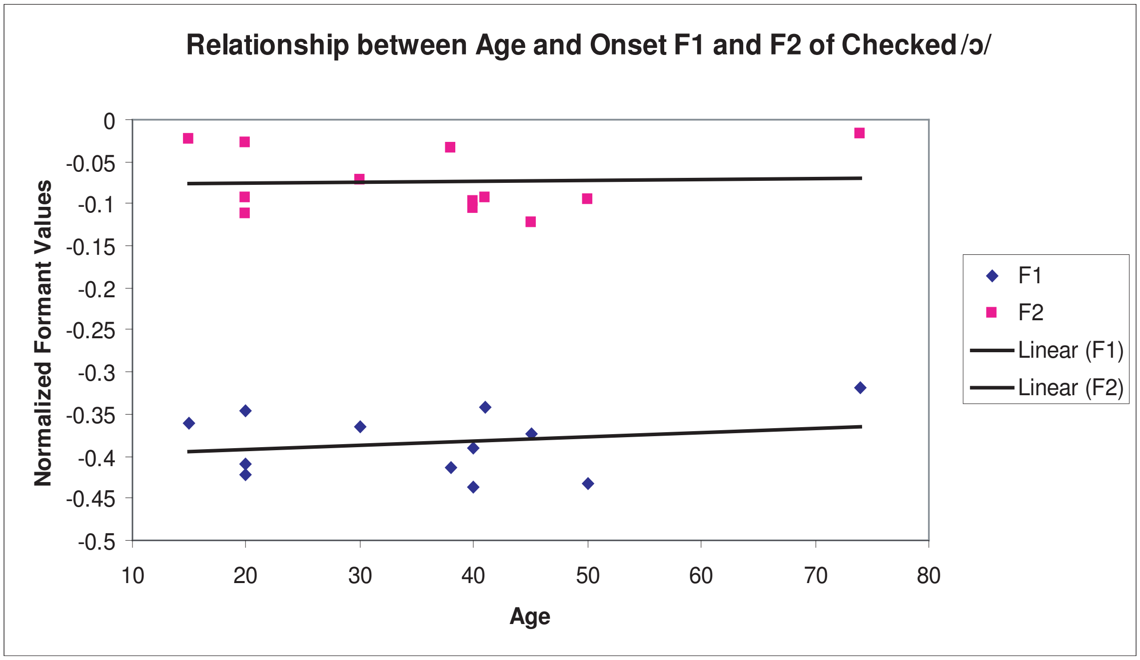


Figure 5.24 : Chart showing the relationship between age and the onset F1 and F2 of checked /ɔ/.

appears to be stable and although there may be a slight correlation with F1 it is not significant (F = 1.022, p = .369). If this were a case of raising, one would expect the onset to show a stronger correlation than the offset, since offsets tend to lag when a vowel is involved in fronting or raising, as shown in Section 5.1.2.1. Thus this is most likely a case of increasing diphthongization. Indeed, for many younger speakers, their /ɔ/ appears to be as diphthongal or more so than /oi/; see, for example, Romero (page 148) and Salina (page 149). For many older speakers, such as Maria (page 143), /ɔ/ appears to be more monophthongal than /oi/, and for the oldest speaker (Rita, page 148), /ɔ/ is very monophthongal. In addition, Rita's /ɔ/ is also unusually low and fronted for a back vowel. Though she only produced three tokens of this vowel, two of *nós* "we" and one of *voz* "voice", all three are pronounced with a monophthongal /a/-like vowel. Since Rita is the oldest participant in the study, at 75 years old, this may be an older variant that is no longer common.

Other interesting observations can be made about the back vowels, although until more data is available, these should be seen as hypotheses to be tested. For many of the the younger speakers in the sample, open /ɔ/ also tends to be fronted, in addition to checked /ɔ/. This can be seen in the charts for Donato (page 137), Priscila (page 147), and Salina (page 149). The fronting of checked and open /ɔ/ is similar the the fronting of checked and open /a/. The checked variants, which are diphthongal for both vowels, are also the ones that are the most fronted. Checked and open /o/ on the other hand, show a different pattern. Although only five speakers produced enough tokens of open /o/ for analysis, the data shows that the open variant is more fronted for some speakers and more backed for others. Interestingly, those for whom the open vowel is more fronted are all over 50 years old (Fabiana, page 138, Rita, page 148, and Tiago, page 151), while the two speakers for whom the checked vowel is more fronted are both under 35 (Donato, page 137, and Vitória, page 151). This may reflect a recent change, whereby /o/ now follows the same pattern as /a/ and /ɔ/.

Fronting of checked /oi/ is common among speakers of all ages, including two of the youngest, Bruna (page 135) and Donato (page 137), and the oldest, Rita (page 148). For these speakers, checked /oi/ is as fronted as /a/ and thus is more of a central vowel than a back vowel. This may be an older change, though it is not clear from the present data what social factors, if any, motivate whether a speaker has a central or back /oi/. One consequence of this is that it has helped keep checked /oi/ and /o/ distinct for most speakers, which is not the case for checked /ai/ and /a/. It is unusual for a variety of a language to maintain a distinction between so many diphthongs in a single region of the vowel space. Perceptual data would be interesting in this case, especially in comparison to other varieties of Portuguese that do not diphthongize pre-/S/ vowels, such as those in small towns in Southern Brazil.

For these varieties, there are only two back upgliding diphthongs, /ɔi/ and /oi/, while in Rio there may be as many as four, as noted in the beginning of this section. It is not known, for example, whether a speaker who distinguishes three or even four back upgliding diphthongs would perceive them as distinct, and whether a speaker from a variety that only has two would be able to perceive such a distinction. (For me, a native speaker of English, which only has one back upgliding diphthong, it is difficult to distinguish between any of the three or four in Portuguese).

A perceptual study on checked /ai/ and /a/ has already been conducted. These results, along with an investigation on which speakers distinguish these two vowels, are presented in the next chapter.

5.3 Merger of Pre-Palatoalveolar /a/ and /ai/ in Open Syllables

As noted in Chapter 1, in addition to the potential merger of /a/ and /ai/ in word final checked syllables, the two sounds also appear to be neutralized in some open syllables in Rio, particularly before /ʃ/. In this case, however, the merger appears to be the result of the monophthongization of /ai/, rather than the diphthongization of /a/: thus *baixo* [baʃu] "low" and *taxa* [taʃa] "tax" both have [a] in Rio. Unfortunately, words like these did not occur frequently in the data in this study, and only one speaker (José) produced more than 3 tokens each of both /a/ and /ai/ in this environment. Thus while it is not possible to comment on any potential variation in the pronunciation of these vowels, an analysis of José's vowels yields some interesting results.

The two vowels do not differ much in terms of the average Cartesian distance between the onset and offset: 218 Hz for /a/ and 207 for /ai/. In terms of the start of formant change, /a/, at 40%, actually shows a slightly sooner start than /ai/, at

63%. In comparison to José's other vowels, the pre-/ʃ/ vowels fall between the open and checked /a/ in terms of the degree of diphthongization, but closer to open /a/. The average Cartesian distance of open /a/ for José is 157 Hz, vs. 538 Hz for checked /a/ and 449 Hz for checked /ai/. The start of formant change of open /a/ also shows that pre-/ʃ/ /ai/ is more on the monophthongal end of the continuum. The average is 63% for open /a/ vs. 11% for checked /a/ and 11% for checked /ai/.

While these data support the claim that open /ai/ is monophthongized before /ʃ/ in Rio, it is interesting to note that there is overlap between the open /ai/ and checked /a/ categories. The most diphthongal tokens of open /ai/ have similar values for Cartesian distance and start of formant change as the most monophthongal tokens of checked /a/ and /ai/. Chapter 4 concluded that environments like pre-palatoalveolar favor diphthongization because the formant transitions going into a palatoalveolar environment are very similar to those of diphthongal vowels with high-front off glides. Considering the data from pre-palatoalveolar /a/ and /ai/, however, it may be more appropriate to rephrase this claim as: it is more difficult to maintain the distinction between monophthongal vowels and diphthongal vowels with a high-front off glide in pre-palatal environments, since both result in formant transitions in the same direction, i.e., a lower F1 and higher F2.

Comparing the effect of the following phonetic environment on glide formation from Chapter 4 (see Figure 4.1) supports this claim. The glides for the pre-palatoalveolar environment are among the most prominent; only the checked /S/ environment shows more prominent glides. Thus the diphthongization of pre-palatoalveolar /a/ must be related to the monophthongization of pre-palatoalveolar /ai/; the merger of the two categories has resulted in a vowel that is intermediate in terms of degree of diphthongization. The fact that misspellings of words containing these vowels occur in both directions, i.e. *taixa* for *taxa* and *baxo* for *baixo*, also supports this idea.

Chapter 6

Perceptual Analysis

While Chapter 5 examined the relationship between social variables and the linguistic data, it did not address whether the checked vowels /a/ and /ai/ were merged or distinct, and if so, for which speakers. This chapter addresses this issue, both in terms of production and perception. Before doing so, however, it is necessary to consider the issue of word frequency, since this has an effect on which words participate in the sound changes outlined in Chapter 5, and to what degree. The production data is examined in Section 6.2, while the results of the perception experiments are examined in Section 6.3.

6.1 Frequency of Usage

The amount of fronting and raising of the checked /a/ and /ai/ onsets is closely related to the frequency with which the words are used, with more frequent words showing the most fronting and raising. This data supports the exemplar model of sound change, as outlined in Bybee (2002), since the change is both phonetically gradual, with speakers exhibiting different degrees of fronting and raising, and lexically diffused.

Table 6.1 shows the number of occurrences of the most frequent words in all of the interviews combined. Raw frequency counts are given, instead of frequencies per million words, since the total number of words in the interviews has not been counted. Only words with 50 or more occurrences are shown. It should be noted that the frequency of some words in the interviews was increased by the fact that many of the interview questions were designed to elicit certain words without the participants re-

Word	Vowel	Number of Occurrences		Avg. Duration (ms)
		Interviews	External Corpus	
mas "but"	/a/	1566	15557	127
mais "more"	/ai/	946	12244	145
dois "two"	/oi/	228	1921	122
faz "does"	/a/	196	2048	143
nós "we"	/ɔ/	147	3693	119
depois "after"	/oi/	135	5322	144
atrás "before"	/a/	131	471	170
arroz "rice"	/o/	84	66	160
paz "peace"	/a/	72	96	197

Table 6.1 : Token frequency of words containing vowels before word final /S/

alizing which words were being elicited. For example, questions about the World Cup in 2002 and 2006 were used to elicit the word *dois* "two", and questions about typical Brazilian foods were used to elicit *arroz* "rice." Of the words shown in Table 6.1, *nós* "we," and *paz* "peace", were also elicited in this way. For comparison, the token frequencies from an external corpus, the spoken portion of *Corpus do Português* (Davies & Ferreira, 2006), are given. In the last column, the avearge duration of the vowel for each word across all 36 speakers is given.

As expected, the function words *mas* and *mais* are by far the most frequent; thus these also tend to be the most fronted and raised. *Mais* is the only word with /ai/ in the list; all other words containing /ai/ in this environment are less frequent. These include plural forms like *hospitais* "hospitals", and words etymologically related to *mais*, namely *demais* "too much" and *jamais* "never." This means that regardless of whether *mas* and *mais* are excluded, words containing /a/ before word final /S/ are

Vowel	**No. of Occurrences**	**Avg. Duration (ms)**
/a/ (incl. *mas*)	2081	136
/ai/ (incl. *mais*)	1189	157
/a/ (excl. *mas*)	515	164
/oi/	378	128
/ai/ (excl. *mais*)	243	201
/ɔ/	194	133
/o/	85	160

Table 6.2 : Sum of the number of occurrences of words containing each vowel

more frequent than those containing /ai/, as shown in Table 6.2. This helps explain why checked /a/ tends to be more fronted and/or raised than checked /ai/ when *mas* and *mais* are considered by themselves, as well as when all other words containing these vowels (i.e. PAZ and PAIS) are considered.

The frequencies of words containing back vowels also reflect the degree of fronting and raising. Checked /oi/ is the most fronted of these vowels for most speakers, and two of the words containing this vowel, *dois* "two" and *depois* "after" occur frequently. In addition, checked /ɔ/ is generally more fronted than checked /o/, and it is a much more frequently occurring vowel. As noted in Section 5.2, *arroz* "rice" is the only common word containing /o/ in this environment, and it occurs less frequently than words like *dois* and *depois*; thus it is the least susceptible to fronting.

All of these trends can also be explained in terms of undershoot. In Section 5.1.3 it was shown that shorter vowels are more likely to be reduced, and thus show more coarticulation between the onset and glide. This results in the onset moving closer to the offset of the glide; thus the onset is fronted and raised. Not surprisingly, the more frequent words in Table 6.2 also tend to be the shortest. Of the words with

/a/ and /ai/, *mas*, the most frequent, has the shortest average vowel duration (127 ms), followed by *mais* (145 ms), *faz* (143 ms), *atrás* (170 ms), and *paz* (197 ms), in order of decreasing frequency. The same pattern is found for the back vowels. *Dois*, the most frequent word, has an average vowel duration of 122 ms, followed by *nós* (119 ms), *depois* (144 ms), and *arroz* (160 ms). Although other factors, such as the number of syllables in the word, affect vowel duration, this effect seems to have been minimized in this case due to the the fact that all the vowels are in word final stressed syllables or monosyllables. Thus the most frequently occurring words have the shortest average vowel durations, which favors more fronting and raising of the onset.

The same information is also reflected in the total number of occurrences of words containing each vowel, as shown in Table 6.2. Checked /a/ occurs more frequently than /ai/, regardless of whether *mas* and *mais* are included in the totals. For the back vowels, checked /oi/ is the most frequent, followed by /ɔ/ then /o/. As expected, the average durations of these vowels increase as word frequency decreases. Similarly, the amount of fronting and/or raising of each vowel follows precisely this order for most speakers, as can be seen in the vowel charts in Appendix A.

Given the relationship between frequency of use, duration, and the amount of fronting/raising, it does not seem appropriate to talk about whether checked /a/ is more fronted or raised than /ai/. While averages for any given speaker may show that /a/ is more fronted or raised, the result is highly dependent on which words are included. A high frequency /ai/ word like *mais* is likely to have a vowel that is more fronted and raised than a low frequency /a/ word like *sagaz* ("sagacious"). Therefore differences in the pronunciation of checked /a/ and /ai/ must be examined on a word-by-word basis, since any difference found between /a/ and /ai/ by averaging different lexical items could be in part or entirely due to differences in the frequency of words

containing these vowels. Since the perceptual portion of the study deals with the minimal pairs *mas/mais* and *paz/pais*, only these pairs of words will be considered in the remainder of this chapter.

6.2 Production

ANOVA tests were used to establish whether the minimal pairs *mas/mais* and *paz/pais* are merged or distinct for each speaker. Since vowels can be distinguished in more than one way, each of the linguistic categories discussed in Chapter 5 were included: Duration, onset and offset F1 and F2, Cartesian distance between the onset and offset, and start of formant change. The non-normalized formant values were used since they are not being compared to other speakers in this case.

Only one speaker (Donato) had more than two tokens each of *paz* and *pais*, and no significant difference was found between these words in his case. Therefore, Table 6.3 focuses on *mas* and *mais*, shows the differences that are significant at $\alpha = 0.05$. Differences in F1 are reported as higher or lower and differences in F2 are reported as fronted or backed. Differences in the Cartesian distance between the onset and offset are expressed as more or less diphthongal. The amount of difference is also shown, as measured in Hertz in the case of formants, milliseconds in the case of duration, or percentage points in the case of start of formant change. For convenience, the social class, age, and sex of each speaker is also given. Speakers for whom there were no significant differences are not shown; the *mas/mais* pair can be assumed to be merged for these speakers.

In almost all cases where a significant difference was found, the distinction is made in the onset, with *mas* either more fronted, higher, or both in relation to *mais*. Differences in duration were found for some speakers, though the difference is small, typically around 50 ms. Although, as shown in Section 5.1.3, the fronting and

Participant	**Class**	**Age**	**Sex**	**Duration**	**Onset**	**Glide**
Ana	Middle	25	F		mas higher* (57 Hz)/fronted* (56 Hz)	mas less diphthongal* (145 Hz)
Beatriz	Lower	40	F		mas fronted* (100 Hz)	
Bruna	Middle/Upper	20	F		mas higher*** (109 Hz)/fronted*** (176 Hz)	mas offset higher*** (73 Hz)
Cláudia	Working	15	F		mas fronted* (115 Hz)	mas offset higher** (99 Hz)
Fabiana	Middle	50	F		mas fronted* (62 Hz)	mas offset higher** (76 Hz)/fronted*** (115 Hz)
Helena	Upper	45	F	mas shorter** (62 ms)	mas higher*** (144 Hz)/fronted*** (254 Hz)	mas less diphthongal*** (265 Hz)
José	Working	20	M		mas fronted* (92 Hz)	mas offset fronted* (195 Hz)
Juliana	Lower	50	F		mas higher*** (153 Hz)	
Laura	Middle	20	F		mas fronted* (88 Hz)	
Liana	Middle	20	F		mas fronted** (133 Hz)	mas offset higher** (74 Hz)
Lucas	Working/Middle	20	M		mas higher* (38 Hz)	
Luisa	Middle	50	F		mas higher** (94 Hz)	mas offset higher* (89 Hz)/backed*** (396 Hz) mas less diphthongal*** (434 Hz)
Maria	Middle	40	F	mas shorter* (44 ms)	mas higher** (129 Hz)/fronted* (79 Hz)	
Marta	Lower/Working	25	F		mas higher** (97 Hz)/fronted** (197 Hz)	mas less diphthongal* (200 Hz)
Mateus	Middle	25	M		mas offset higher** (92 Hz)	
Olívia	Middle	40	F		mas higher* (105 Hz)	mas offset higher* (111 Hz)
Oscar	Working	20	M		mas fronted** (98 Hz)	
Paula	Lower/Working	20	F			mas offset higher* (118 Hz)
Pedro	Middle	25	M	mas shorter* (58 ms)	mas higher* (38 Hz)	
Priscila	Lower/Working	20	F		mas fronted* (54 Hz)	
Romero	Middle	20	M		mas higher*** (42 Hz)/fronted** (58 Hz)	mas less diphthongal* (98 Hz)
Salina	Upper	15	F		mas higher*** (99 Hz)/fronted* (95 Hz)	mas less diphthongal* (190 Hz)
Sofia	Middle	35	F	mas shorter* (48 ms)	mas higher* (61 Hz)/fronted* (147 Hz)	mas less diphthongal* (237 Hz)
Susana	Lower	40	F	mas shorter* (54 ms)	mas higher** (94 Hz)	mas less diphthongal* (211 Hz)
Taís	Middle	20	F		mas higher*** (122 Hz)	mas offset higher*** (61 Hz)/less diphthongal* (148 Hz) mas formant change later (19%)
Vitória	Upper	35	F	mas shorter** (55 ms)	mas higher*** (161 Hz)/fronted*** (188 Hz)	mas less diphthongal** (284 Hz)

Table 6.3 : Differences in the production of *mas* and *mais* per speaker, based on multivariate ANOVA (*$p < .05$; **$p < .01$; ***$p < .001$)

raising of the onset is likely due to undershoot and vowel reduction, it is not merely a consequence of the vowel in *mas* being shorter than the vowel in *mais*; for most of the speakers for whom the *mas* onset is fronted and/or raised, there is no significant difference in the average duration of the *mas*/*mais* vowels.

There do not appear to be any social motivations for which speakers merge the *mas* and *mais* vowels and which ones distinguish them. Speakers of all ages, social classes, and both sexes appear in Table 6.3. The average age of participants who distinguish the vowels (29) is less than the average age of those who merge them (38), but the difference is not significant (Two-tailed t-test assuming unequal variances; $p = 0.14$)

Many speakers also show significant differences in the offset, though most of these differences are likely related to the fronting or raising of the onset. With only one exception, when the *mas* offset is different from the *mais* offset, it is the *mas* offset that is higher or more fronted. This is likely a result of the fronting and raising of the onset, as explained in section 5.1.2. The same is true for most of the differences found in Cartesian distance. Although in other varieties of Portuguese, such as in Southern Brazil, *mas* may be more monophthongal than *mais* because it is not undergone as much diphthongization, for the speakers in Rio, this difference in glide intensity seems to be due to the fronting and raising of the onset. This results in an onset that is closer to the high-front glide target, thus reducing the Cartesian distance between them. This can be clearly seen in many of the vowel charts, such as Helena (page 139), Susana (page 150), and Vitória (page 151).

The only exceptional case in this study is Luisa. She has the only example of a *mas* offset being more backed than *mais*. Whereas for the other speakers who show a difference in Cartesian distance between *mas* and *mais*, the difference is generally less than 250 Hz, with only a few speakers (Vitória and Helena) approaching 300 Hz.

For Luisa, the difference is much greater, at 434 Hz. Thus Luisa stands out as being the only speaker for whom *mas* is less diphthongal than *mais* because the glide target is more backed than that of *mais*. This distinction is clearly illustrated on her vowel chart (page 143).

6.3 Perception

The perceptual component of this study was not part of its original design; it was added later as the data was being collected. A self-reporting test, in which participants were asked whether the minimal pairs *mas/mais* and *paz/pais* were the same or different in their own speech and in the speech of others, was added in 2008, when 19 of the 36 interviews were conducted. This test was done after each interview was completed, and speakers were not aware of the nature of this test before the interview. In 2009, I attempted to recontact the participants from 2008 to do a discrimination task to see if they were able to discriminate between the *mas/mais* and *paz/pais*. Only 7 of the 19 participated in this part of the study, since some were not available, and others were not able to be contacted.

Section 6.3.1 discusses the results of the self-reporting test, while Section 6.3.2 discusses the discrimination test.

6.3.1 Self-Reporting Perception Test

While the interviews themselves were conducted by natives of Rio de Janeiro, I decided to do the perception test myself, since it may seem more natural for a non-native speaker to ask questions related to how a given pair of words are pronounced.

Each participant was asked to repeat the following two sentences:

O Mercedes é um bom carro, ***mas*** *o Fusca é* ***mais*** *em conta.*

"The Mercedes is a good car, but the Beetle is more economical."

Meus ***pais*** *rezam pela* ***paz.***

"My parents pray for peace"

The sentences were designed so that the pronunciation of the final consonant of *mas/mais* and *paz/pais* would be the same for each pair. Thus both *mas* and *mais* are followed by a vowel, resulting in the final *-s* being pronounced [z] in both words. Since *pais* is followed by a voiceless consonant (*rezam*: [hɛzõ]) and *paz* is followed by a pause, it was expected that the final *-s/z* would be pronounced [ʃ] in both cases. However, it was later discovered that not all speakers treat [h] as a voiceless consonant, with some pronouncing *pais rezam* as [pai**ʒh**ɛzõ] and other as [pai**ʃh**ɛzõ]. This factor was taken into consideration when analyzing the results. In the first sentence, "Mercedes" and "Beetle" were selected as typical expensive and inexpensive cars in Brazil.

Since some of the lower class participants may be illiterate or semi-literate, the sentences were read aloud for all speakers. In my own pronunciation, I pronounce both checked /a/ and /ai/ as [ai], making no attempt to differentiate them. After the participant repeated each sentence, they were asked to pay attention to two words in boldface, and I read the sentences again with these words emphasized. They were then asked whether they thought these words were the same or different in their own pronunciation, and whether they thought they were the same or different for other people. Table 6.4 shows the results for each of the 19 participants who participated in this self-perception test. A summarized version of the production data from Table 6.3 is repeated for comparison.

The most striking aspect of the results is how little the participant's self-observations about their own speech match their own production data. All combinations of results can be found: those who claim to produce a difference but do not (eg. Alberto, Rita), those who claim to produce a difference and do (eg. Cláudia, Liana), those

				mas* vs. *mais			***paz* vs. *pais***		
				Perception		**Production**	**Perception**		**Production**
Participant	**Class**	**Age**	**Sex**	**Self**	**Others**		**Self**	**Others**	
Alberto	Lower/Working	40	M	Diff.	Doesn't know	Same	Diff.	Doesn't know	n/a
Bruna	Middle/Upper	20	F	Same	Same	Diff.	Same	Same	n/a
Cláudia	Working	15	F	Diff.	Diff.	Diff.	Diff.	Same	n/a
Donato	Middle	20	M	Same	Diff.	Same	Diff.	Doesn't know	Same
Fabiana	Middle	50	F	Same	Same	Diff.	Same	Diff.	n/a
Geraldo	Working	30	M	Same	Doesn't know	Same	Same	Doesn't know	n/a
Helena	Upper	45	F	Same	Same	Diff.	Same	Same	n/a
Humberto	Working	30	M	Same	Same	Same	Same	Same	n/a
Leonardo	Lower	40	M	Same	Diff.	Same	Diff.	Diff.	n/a
Liana	Middle	20	F	Diff. (intonation)	Diff.	Diff.	Diff.	Diff	n/a
Olívia	Middle	40	F	Same	Doesn't know	Diff.	Same	Doesn't know	n/a
Oscar	Working	20	M	Same	Diff.	Diff.	Same	Same	n/a
Paulo	Working	40	M	Same	Same	Same	Diff.	Diff.	n/a
Rita	Working	75	F	Diff.	Diff.	Same	Diff.	Diff.	n/a
Romero	Middle	20	M	Same	Diff.	Diff.	Same	Same	n/a
Salina	Upper	15	F	Same	Diff.	Diff.	Diff.	Diff.	n/a
Taís	Middle	20	F	Same	Same	Diff.	Diff.	Diff.	n/a
Tiago	Lower	55	M	Diff.	Diff.	Diff.	Diff (intonation)	Diff	n/a
Vitória	Upper	35	F	Same	Diff.	Diff.	Diff.	Diff.	n/a

Table 6.4 : Results of the self-reporting perception test for *mas* vs. *mais* and *paz* vs. *pais*

who do not claim to produce a difference and do not (eg. Donato, Geraldo), and those who do not claim to produce a difference but do (eg. Helena, Romero). Thus people's intuitions about their own pronunciations in this case bare no resemblance to their actual production. Even Bruna, who distinguishes *mas* and *mais* more at longer durations than shorter durations (see Section 5.1.3 and Figures 5.18 and 5.19) claimed that the two words were the same for her. While, Cláudia, who also makes a greater distinction at longer durations, claimed that they were indeed different, she was indecisive, first claiming they were the same, then different. There does not seem to be any relationship to the participants' self-reporting and their age, sex, or social class.

Many more participants reported that they pronounced *paz* and *pais* differently than *mas* and *mais*. This may be due to the fact that some participants produced a voiced final consonant in the word *pais* before [h], while others produced a voiceless consonant. Of the seven participants who produced a voiced consonant, all but Olívia claimed that *paz* and *pais* were different. Nonetheless, some speakers responded differently to the *paz*/*pais* pair than to the *mas*/*mais* pair, even those who used a voiceless final consonant for both *paz* and *pais*: this is true for Leonardo, Salina, and Taís, all of whom claimed than *mas* and *mais* were the same but *paz* and *pais* were different. There are several possible reasons for this type of response. The potential merger of *mas* and *mais* has already reached the level of consciousness for most speakers. They are frequently confused in writing, and students are often taught in school that they should be pronounced differently. Many participants, however, said that they had never noticed that *paz* and *pais* were the same or similar. Those who claimed they were different may have been influenced by the morpheme boundary in *pais* (*pai* + *-s*), or even the intonation of the words. Tiago, for example, said that the pronunciation of *paz* and *pais* was the same, but the intonation was different.

The data on whether the participants thought other people pronounce these words differently also bear no resemblance to their own self-assessment nor to their actual production. Although a few participants said they were not sure or had not noticed, most were at least willing to take a guess. Only one participant (Rita) claimed that everybody, herself included, pronounced all the words differently without qualifying or hedging her answer. Many said that some people pronounced them differently while others pronounced them the same. Several accurately noted that the pronunciation varies by region, saying that the words are the same in Rio, but may be different in other parts of Brazil. Interestingly, one participant (Cláudia) claimed that she differentiated *paz* and *pais* but other people did not, though she hedged her self-assessment with "different, maybe sometimes the same."

A few participants imitated the way other people pronounce *mas* to differentiate it from *mais*. Their imitations invariably had word-final [s] instead of [ʃ], and most were lower, more backed, and more monophthongal than their own pronunciations. Thus they appear to be imitating the way *mas* is pronounced in some regions of Brazil, that is [mas]. In addition to providing some imitations of monophthongal *mas*, Cláudia made some of the most revealing remarks on her perceptions and attitudes toward this word.

> Eu, antes, eu falava [maiʃ], tudo [maiʃ]. Aí uma professora minha de quarta série falou assim: "não é [mais]" sem o "i", falava assim, "não é [maiʃ], é [məs], [məs]." Aí eu, "ah tá." Aí eu cheguei no segundo grau, "não, não precisa ficar falando [məs] porque é só ver pelo contexto." Aí eu, "ah tá." Aí eu, "tá, tudo bem," né? Mas ([mɛz]) aí eu já tinha me acostumado. Mas ([mæʒ]) normalmente é o [maiʒ] diferente, mas ([mæʒ]) não chega ao [məz] assim.
>
> *Before, I used to say [maiʃ], all [maiʃ]. But then a teacher of mine in*

the fourth grade said, "it's not [mais]" without the "i", she said "it's not [maiʃ], it's [məs], [məs]." So I'm like "Oh, OK." And then I got to high school and they're like "no, you don't need to say [məs] because you can tell from the context." So I'm like "Oh, OK." I'm like "OK, that's fine," right? But ([mɛz]) I had already gotten used to it. But ([mæʒ]) normally it's the different [maiʒ], but ([mæʒ]) it doesn't reach [məz] like that.

Her imitations of the way her teacher told her *mas* should be pronounced are much higher and more backed than her own natural pronunciations. Her unlikely tale of how one teacher permanently altered her pronunciation was eventually hedged when she said "but normally it's the different [maiʒ], but it doesn't reach [məz]." In the process of saying this, she produced three natural tokens of *mas* "but", all of which were very fronted, reaching [æ] and [ɛ]-like vowels. In her own production, *mas* tends to be more fronted than *mais* (see Table 6.3), though her imitations of monophthongal *mas* has a more backed vowel. Furthermore, the final consonant follows the normal pattern of assimilation to the following word (see Section 1.1), instead of the [s] that her teacher taught her.

These comments suggest that prescriptivist ideas about how *mas* should be pronounced may be the reason that some of the participants self-reported than *mas* and *mais* are different. Her comment that one teacher told her that *mas* should be pronounced differently while others said it doesn't matter may reflect changing views on the subject. Since diphthongization of *mas* appears to be universal in Rio, many people have accepted it as a regional variant, and given the fact that the Rio variety is the most prestigious in Brazil (see Section 2.2), they are unlikely to feel insecure about this pronunciation. It remains ironic that for some speakers in Rio, there actually is a difference between *mas* and *mais*, but it is not the same as the one that is prescribed in classrooms, and it appears to be below the level of consciousness.

		SPOKEN	
		same	different
JUDGED	same	(a) 5	(b) 9
	different	(c) 2	(d) 3

Table 6.5 : Number of participants who judged and pronounced the pairs of words *mas/mais* the same and differently (modeled after Labov et al. [1991]).

6.3.2 Discrimination Perception Test

The results from the self-reporting test closely resemble those found for near-mergers, as discussed in Labov et al. (1991). The data from Table 6.4 can be summarized in a four-cell table, as shown in Table 6.5, modeled after one found in Labov et al. (1991).

The existence of participants who fall in cells (b) and (c) highlights the lack of symmetry between production and perception. Even those in cell (d) in this case show this lack of symmetry, since the difference they produce is not always the same one they claim they produce (see the description of Cláudia in Section 6.3.1). As explained in Labov et al. (1991), the existence of participants in cell (b), in which speakers produce a difference that they are unable to perceive, is particularly interesting because it challenges assumptions about the discreteness of phonemes, as well as the reliability of introspective data.

To examine this phenomenon further, a discrimination test, modeled after Labov et al.'s commutation test, was conducted with seven of the participants. About 15 tokens each of *mas* and *mais* were isolated from each of the participants' interviews. The tokens were chosen to include vowels along three different continua: the front/back and high/low continua in the vowel space, along with the monophthongal/diphthongal continuum. This will make it possible to determine which of these three continua was the most useful in helping participants to identify a given word

as *mas* or *mais*. Tokens of *paz* and *pais* were also included, although since these words are less frequent, there were only two or three tokens available (if any) for most participants.

A computer program was used to randomize the list of tokens and present them to the participant as a forced choice experiment. The participants heard the words from their own interview and were asked to click on the button labeled MAS if they thought the word was *mas*, and MAIS if they thought the word was *mais*. The *paz/pais* experiment was done in the same way, although only Alberto and Donato had sufficient tokens of these words to test.[1] Two participants (Fabiana and Donato) also gave permission to let other participants attempt to identify the words from their interviews. Thus most participants performed the test for their own speech as well as the speech of two other participants. After the experiment, each participant was asked two questions: (a)Do you think you were able to distinguish the words? (b) What did you use to try to distinguish them? For example: tone of voice, intonation, sound of the word.

Table 6.6 shows the percentage of correct identifications of each word pair for those who participated in this experiment. The participants in this experiment are labeled as "listeners," while the interviews from which the words were extracted are labeled as "speakers," with "Self" indicating that the participants were listening to words extracted from their own interviews. *Mas* and *paz* indicate which word pair they were attempting to identify: *mas/mais* or *paz/pais*, respectively

While none of the participants were able to correctly identify the words 100% of the time, one-tailed binomial tests were used to see if the proportion of correct

[1]Although Alberto produced a total of nine tokens of *paz/pais*, only two were of *paz*; thus there were enough tokens overall for the discrimination task, but not enough of *paz* to be included in the production ANOVA described in Section 6.2

Listener		Speaker				
		Self:*mas*	Self:*paz*	Fabiana:*mas*	Donato:*mas*	Donato:*paz*
	Alberto	56%	56%	41%	66%	62%
	Cláudia	66%	n/a	59%	56%	69%
	Donato	**68%***	**77%***	59%	—	—
	Fabiana	56%	n/a	—	47%	69%
	Helena	63%	n/a	44%	25%	46%
	Paulo	33%	n/a	65%	42%	69%
	Romero	61%	n/a	66%	50%	31%

Table 6.6 : Percentage of correct identifications of MAS/MAIS and PAZ/PAIS (*significantly higher than 50% at $p < .05$)

identifications was significantly higher than 50%. P-values of .05 or more indicate the participant was unable to identify the word better than what would be expected by chance (i.e. 50%). As shown in Table 6.6, only Donato, when listening to his own speech, was able to identify the words pairs significantly better than chance. This is surprising given that Donato was not one of the participants who showed a significant difference between either word pair. Of those who participated in the discrimination experiment, only Cláudia, Fabiana, Helena, and Romero show a significant difference for *mas* vs. *mais*, and Helena and Romero for *paz* vs. *pais*. (see Table 6.3). Since the words to be included in the experiment were not chosen randomly, but rather represent the extremes of three different continuua (front/back, high/low, monophthongal/diphthongal) the fact that Donato was able to perform significantly better than chance does not necessarily contradict the fact that no significant difference was found for either word pair in his speech.

These results further highlight the gap between the participants' self reporting and

their actual behavior. Neither of the participants who reported that they pronounced *mas* and *mais* differently (Alberto and Cláudia) were able to correctly identify the words in their own speech; of the four who reported that they pronounced *paz* and *pais* differently, (Alberto, Cláudia, Donato, and Paulo), only Donato performed above chance in identifying the words. If most of the participants were unable to use the linguistic cues present in their speech to identify the words, what cues (if any) were they using? To help answer this question, ANOVA tests were used for each listener/speaker combination to see if any of the linguistic data (duration, F1 and F2 of the onset and offset, Cartesian distance, and start of formant change) significantly correlated with their responses. Thus this does not test whether their responses were right or wrong, but rather indicates what linguistic information was used to arrive at their responses. The results that are significant at $\alpha = .05$ are shown in Table 6.7.

The results indicate that some speakers make use of the linguistic information analyzed in identifying the words, while others do not. Alberto and Paulo's choices do not appear to be based on any of the linguistic information included, except for Cartesian distance in the case of Paulo's identification of Donato's *mas/mais* words. Alberto admitted that he does not think he was able to distinguish the words and that he was just guessing for most of them. Paulo, on the other hand, indicated that he thought he was able to distinguish them, based on the "sound and intonation" of the words.

Fabiana represents a special case since she guessed *mais* for nearly all of the tokens in *mas/mais* tests. She does appear to have made use of the offset F2 in identifying Donato's *mas/mais* words; she answered *mais* for all of them except for one that had an unusually low offset F2, which makes it sound more monophthongal (though it was actually a token of *mais*). When asked if she thought she was able to distinguish the words, she said "yes, 90% of them had *i*", indicating she thought most of them were

		Speaker				
		Self:*mas*	Self:*paz*	Fabiana:*mas*	Donato:*mas*	Donato:*paz*
Listener	Alberto	n.s.	n.s.	n.s.	n.s.	n.s.
	Cláudia	Onset F2*	n/a	Duration*** Onset F1*/F2* Cart. Dist.*** Offset F2*	Duration** Onset F1* Cart. Dist.** Offset F2**	Duration*
	Donato	Duration*	Duration* Cart. Dist.* Offset F2*	Duration*** Onset F1*/F2** Cart. Dist.*** Offset F2***	— —	— —
	Fabiana	n.s.	n/a	—	Offset F2*	n.s.
	Helena	Cart. Dist.*	n/a	n.s.	n.s.	Duration* Onset F1* Cart. Dist.** Offset F2*
	Paulo	n.s.	n/a	n.s.	Cart. Dist.*	n.s.
	Romero	Duration*** Onset F1***/F2* Cart. Dist.**	n/a	Duration*** Onset F1* Cart. Dist.**	Duration** Cart. Dist.**	n.s.

Table 6.7 : Significant correlations between linguistic information and listener's responses in the perception experiment, based on ANOVA (*$p < .05$; **$p < .01$; ***$p < .001$; n.s. = not significant).

mais. She claimed that *mais* was spoken with more certainty, while *mas* was more prolonged. Although she did not comment on the *paz/pais* test for Donato, she did make more of an effort to identify these words. Although she did slightly better with these (she got 69% right) the result was not significanly better than 50% (p = .1134).

The results for the remaining four participants show that they were not merely guessing for most of their responses. They frequently used duration and Cartesian distance in making their decisions, and occasionally, the onset and offset F1 and F2 as well. Cláudia, who had insisted that she distinguished *mas* and *mais* in her own speech, apparently used the onset F2 to distinguish the words. Despite what her fourth grade teacher had instructed her about the pronunciation of *mas* (see Section 6.3.1), namely that it should have a high central vowel like [məs], she tended to respond *mas* for tokens with front vowels and *mais* for tokens with more centralized vowels. This strategy helped her to identify the words correctly 66% of the time, and the binomial test is nearly significant at p = 0.068. When asked if she thought she was able to distinguish the words, she said she thought so; she said the difference was that "*mais* has an *i*, and *mas* is spoken more quickly." What is most interesting about her answer is that it reflects neither own performance on the perception test nor her own pronunciation. As indicated, her responses were based more on the onset F2 than duration of the quality of the offset. Even if she had used duration or glide information as the basis of her responses, it would not have helped her; her *mas* vowels are actually longer on average than her *mais* vowels, and the offset of *mas* is actually higher, and thus closer to [i], than *mais*.

Cláudia apparently used different strategies when listening to Fabiana and Donato's words, relying more on duration and Cartesian distance, and to a lesser extent, the onset and offset formants. The average duration of her *mais* responses was 148 ms for Fabiana and 195 ms for Donato, compared to the average duration of her *mas*

responses of 88 ms for Fabiana and 116 ms for Donato. A similar difference is found for Cartesian distance. The average Cartesian distance of her *mais* responses was 651 Hz for Fabiana and 497 Hz for Donato, while the average Cartesian distance of her *mas* responses was 283 Hz for Fabiana and 293 Hz for Donato. This indicates that she tended to respond *"mais"* for longer more diphthongal tokens and *"mas"* for shorter, more monophthongal tokens. This is precisely what she claimed to be doing, when she said that "*mais* has an *i*, and *mas* is spoken more quickly."

The fact that F1 tends to increase and F2 tends to decrease with duration (see Section 5.1.3) this likely explains the correlations with onset F1 and F2. The correlations with offset F2 are likewise related to the correlation with Cartesian distance, as F2 offsets are necessarily higher for more diphthongal vowels. It is interesting that Cláudia used different strategies for identifying her own vowels than those of the other speakers. This may reflect her belief that she produces a difference between the vowels while many other speakers do not. Although she knows Fabiana personally (they are neighbors), she does not know Donato; nonetheless she uses similar strategies for both speakers.

Romero, who is Fabiana's son, uses a similar strategy for both his own speech and the other speakers, relying mostly on duration and Cartesian distance. For his own vowels, he responded *mas* for 43 of the 49 tokens tested, responding *mais* for only the longest and most diphthongal tokens. The average duration of his *mais* responses was 253 ms, with an average Cartesian distance of 804 Hz; the average duration of his *mas* responses was 111 ms, with an average Cartesian distance of 381 Hz. In his own speech, however, the difference in F1 and F2 is a more reliable way of distinguishing the words than the difference in Cartesian distance. Although his *mais* responses did have a higher F1 and lower F2 than his *mas* responses, this difference was not as great as the differences between duration and Cartesian distance, suggesting that the

later were the main factors motivating his choices. As a result, his correct responses were not significantly better than chance.

A similar situation occurred for Helena. Her responses were based mostly on the Cartesian distance of the tokens, and the average Cartesian distance of her responses (645 Hz for *mais* and 392 Hz for *mas*) were remarkably close to the overall averages of the tokens she produced (659 Hz for *mais* and 394 Hz for *mas*). The reason her correct responses were not significantly better than 50% was that the tokens selected did not accurately reflect this difference, instead reflecting the differences in onset F1 and F2.

This also explains how Donato was able to correctly identify the words better than chance, despite not having any significant differences between his *mas* and *mais* vowels. Although the average F1, F2, and Cartesian distance of the tokens included in the test were similar to his overall averages, the average duration of the *mais* tokens included was longer than that of his *mas* vowels, allowing him to use this difference to correctly identify the words 68% of the time for *mas*/*mais*. For his *paz*/*pais* pair of words, fewer tokens were available, so all of them were included in the experiment. Since the average duration of his *pais* vowels is slightly longer than his *paz* vowels (152 ms vs. 124 ms), this allowed him to correctly identify 77% of the tokens. The average duration of his *pais* responses (228 ms) is much greater than the actual average duration of his *pais* vowels (152 ms), thus while he identified the longer tokens of *pais* correctly, he indentified the shorter tokens of *pais* as *paz*.

6.4 Conclusions

The design of this experiment could be improved by including all available tokens in the experiment, or at least including enough tokens so that all of the linguistic factors are well represented. Despite this limitation, the results indicate that under

the right circumstances, listeners are able to distinguish between the minimal pairs *mas*/*mais* and *paz*/*pais* at above chance levels, but not with 100% accuracy. Most speakers rely on a combination of linguistic factors to attempt to distinguish them, but duration and Cartesian distance tend to predominate, as reflected in the ANOVA test in Table 6.7 and the average values of their responses. Only Cláudia based her responses on the onset alone. The result is that most speakers perform poorly on the discrimination task partly because they do not base their responses on the linguistic information that is most useful, namely the onset formants. As shown in Table 6.3, these word pairs are much more likely to be distinguished by their onsets than other factors like the degree of diphthongization.

The participants' answers to the question about what they used to try to distinguish the words reflects their predominate use of duration and Cartesian distance. Four of the participants mentioned something about "velocity" or one word being faster than another, while three mentioned something about the end of the word being different or *mais* having an "i." These comments likely reflect the speakers' prescriptive beliefs about how these words should be pronounced, beliefs that appear to be learned in school and reinforced by the orthography. It would be interesting to compare these responses to those of illiterate speakers or speakers with little education, though all of the participants in the discrimination task had at least some high school education.

Speakers appear to be mixed on whether or not they believe that these word pairs are pronounced differently, and whether or not they think they can distinguish them. Of the seven participants in this experiment, only Alberto and Cláudia said that they thought they pronounced *mas* and *mais* differently, when asked after their interviews in 2008. After the perception experiment in 2009, however, four said that they thought they were able to distinguish them (Cláudia, Fabiana, Romero, and

Paulo), although Fabiana said this because she thought the majority of the tokens were *mais*. Only Cláudia was consistent in her self-evaluation that the words were or should be different, claiming in 2008 that she pronounced them differently and in 2009 that she was able to distinguish them. This may reflect varying attitudes about these words, with some speakers believing that there is no problem pronouncing these words identically, while others believing they are or should be distinguished. The fact that the speech of Rio is usually considered the standard form of Brazilian Portuguese (see Section 2.2) may help create some linguistic security among its residents. But as Cláudia's comments in Section 6.3.1 indicate, attitudes about *mas* and *mais* are not uniform within the community. Speakers often receive conflicting information about these words; many are taught in school that they should be distinguished, yet diphthongizing checked /a/ is one way that speakers from other regions can make their speech sound more *Carioca* (see Section 2.7). It is hard to maintain a belief that a particular aspect of one's speech is wrong when speakers from other varieties sometimes seek to emulate it.

The perceptual and production data on checked /a/ and /ai/ are similar to cases of near mergers. Table 6.5 summarizes the lack of symmetry between perception and production, and the degree of separation in the vowel space is within the range found for reported cases of near mergers, not exceeding 200 Hz (see Table 6.3). However, as explained in Section 6.1, the degree of fronting and raising of checked /a/ and /ai/ is best explained by frequency of use; if checked /a/ is more fronted and/or raised than checked /ai/ for any given speaker, it is due to the fact that words containing /a/ in the pre word final /S/ environment are more frequent than those containing /ai/. Thus this does not appear to be a sound change that started with /a/ and is now spreading to /ai/; instead, it appears to be affecting both /a/ and /ai/, starting with the most frequently occurring words and spreading to less frequent words. This

suggests that /a/ and /ai/ are neutralized in the pre word final /S/ environment, since fronting and raising affects both vowels. Indeed, if the word *mas* were excluded from the analysis, then /ai/ would appear to be the most fronted and raised overall, since *mais* would then be the most frequently occurring word in the analysis.

Therefore, it can be argued that the existence of speakers who produce a distinction in production that they are not consciously aware of does not in itself define a near-merger. Near mergers are typically distinctions that were historically viable, but have become less reliable as a means of distinguishing two sounds due to close approximation of the two categories in production. This can be seen in cases like the SOURCE and SAUCE vowels in New York City (Labov et al. 1991), and between tense and lax vowels before /l/ (eg. POOL and PULL) in Salt Lake City (Faber & Di Paolo, 1995). In these cases, the distinction made by speakers with a near merger is similar to the one made by speakers who fully distinguish the vowels, only to a lesser degree. In the case of checked /a/ and /ai/ in Rio, both vowels are fully diphthongal for most speakers (with the exception of Luisa); thus the monophthongal/diphthongal distinction made in some varieties of Portuguese has been lost for most speakers in Rio.

It is possible, of course, that the durational difference between /a/ and /ai/ in the data from this study is an artifact of the original monophthongal/diphthongal distinction. Although historical data would be needed to confirm whether this is the case, it seems unlikely given the data on duration discussed in Section 6.1. Lexical frequency has a larger effect on vowel duration than the historical distinction between /a/ and /ai/. The checked /ai/ vowel is only 21 ms longer on average than the checked /a/ vowel (157 vs. 136 ms). On the other hand, low frequency words with either vowel are 43 ms longer on average than high frequency words with either vowel (177 vs. 134 ms, with *mas* and *mais* defined as high frequency and all others defined as low

frequency). This suggests that lexical frequency is the important factor in this case, and that the durational difference between /a/ and /ai/ is merely an artifact of this frequency difference.

The distinction between *mas* and *mais* in terms of onset F1 and F2 appears to be an example of a homonym split, rather than a near-merger in the way it has typically been defined. This is similar to the case of tense *tin* ***can*** [keən] and lax *I* ***can*** [kæn] in some varieties of American English (eg. Philadelphia, Labov 1994), except that in the case of *mas* and *mais*, both words are high-frequency function words. The data for checked /a/ and /ai/ in Portuguese provide strong evidence for the claim that high frequency words undergo vowel shifts before low frequency words (Bybee, 2002). It even suggests that the relationship between word frequency and the degree of participation in the vowel shift is scalable; that is, the higher the frequency of the word, the more the vowel tends to be fronted and raised.

Chapter 7

Conclusions

The phonetic data analyzed in this dissertation provide compelling insight into the process of diphthongization. This is one of the few sociolinguistic studies to examine diphthongization as a conditioned sound change. Most of the conditioned sound changes examined in English and other languages have been related to changes within the vowel space, such as in chain shifts and mergers. By using a reliable and replicable methodology for measuring diphthongs, it was possible to show how diphthongization is related to coarticulation with the following phonetic environment. The results from Chapter 4, which examines how the formant transitions of back vowels are affected by the following phonetic environment, helps explain why pre-palatal and pre-alveolar environments tend to favor diphthongization both historically (see Chapter 1, Table 1.1) and synchronically (Chapter 5). Since these environments have formant transitions similar to those of diphthongs with glides in the direction of [i], the distinction between monophthongal and diphthongal vowels in these environments is minimized, creating overlap between the two types of vowels. This increases the likelihood that members of the monophthongal class of vowels will switch to the diphthongal class (eg. *mas* [maiʃ]), and in some cases vice versa (eg. *baixo* [baʃu]).

It is tempting to look for phonetic motivations to explain why the diphthongal variants are favored in checked syllables (eg. *mas* [maiʃ] "but") while open syllables favor monophthongal vowels (eg. *baixo* [baʃu] "low"). One possibility is that duration may play a role. Shorter vowels are more affected by formant transitions than longer vowels; in fact Stevens (1998) calculated that at durations less than 200 ms,

surrounding consonants could have an effect on the vowel throughout its length. However, based on the data in this study, vowel duration does not seem to be a factor in determining whether a vowel in a particular context will be diphthongal or monophthongal. Vowels in open syllables are not consistently longer than vowel in checked syllables across all speakers; the average durations for each environment (calculated by averaging the averages of each speaker) are fairly similar: 156 ms for open /a/, 144 ms for checked /a/, and 166 ms for checked /ai/. Furthermore, diphthongization is only favored by word-final checked syllables; word-medial checked syllables remain more monophthongal (eg. *gasta* [gaʃta] "spend").

A more likely explanation is that the word final environment favors diphthongization because it is the most salient: of all the environments in which /ʃ/ occurs in the Portuguese of Rio de Janeiro, word final is by far the most frequent. This can be shown by comparing the token frequency of all words occurring in the interviews that contain the vowels /a/, /ɔ/, and /o/ (and their diphthongal counterparts) before a palatoalveolar consonant (voiced or voiceless) in stressed syllables. The following frequencies are from the spoken portion of the *Corpus do Português* (Davies & Ferreira, 2006), grouped by the position of the consonant: word final (eg. *mas*) 22692, intervocalic (eg. *baixo*) 4185, word medial syllable final (eg. *gasta*) 1485 (tokens per million words). Thus words with /ʃ/ in word final position are four times as frequent as the other two positions combined. This suggests that salient words in a phonetic environment that favors large formant transitions (in this case alveolar and palatoalveolar) are the most likely to undergo diphthongization.

The data also reveals that checked /a/ and /ai/, which are both fully diphthongal for most speakers in Rio, are becoming increasingly fronted and/or raised. The fronting of /ai/ to [e] or similar is widely attested in other languages, both those that are closely related and unrelated to Portuguese. The cognates of Portuguese

mas/mais in French (*mais* [mɛ] "but") and Catalan (*més* "more") both have front vowels. Classical Latin /ai/ became /e/ or similar in most modern Romance languages, as in Latin *aetās*, Italian *età* "age." The same change is also attested in Pali (cf. Sanskrit *maitrī*, Pali *mettā* "goodwill, friendship"), Gothic (cf. Old Gothic *áins*, Old Saxon *ēn* "one"), and in Yami, a language of Taiwan (eg. *mangay* ∼ *mangey* "go"; Rau et al. 2006). The data from Rio de Janeiro provide an opportunity to study the beginnings of this type of change, before speakers have become aware of it. The undershoot phenomenon, described in 5.1.3, provides a likely phonetic motivation for this change, one that may have played a part in the change from /ai/ to [e] in other languages as well.

The data in this study supports the idea that lexical frequency affects language structure (Bybee & Hopper, 2001). The fact that low frequency words have longer average vowel durations than high frequency words is well established (see Section 6.1). Undershoot is also a well-established phenomenon, having been proposed as a mechanism of language change in other languages (see Section 5.1.3). However, the increased fronting and raising of checked /a/ and /ai/ is not merely an articulatory consequence of vowel reduction. For some speakers, particularly Bruna (see Tables 5.18 and 5.19), checked /a/ and /ai/ have split such that even when duration is equal, /a/ still tends to be more fronted and raised than /ai/. This shows how speakers' experiences with phenomena like vowel reduction can ultimately reshape their linguistic categories.

In addition to providing valuable data on diphthongization, this dissertation is also an important contribution to sociolinguistics in Brazilian communities. The findings from Chapter 5 support the claim in Chapter 2 (Section 2.4) that, contrary to popular opinion, favela residents in Rio do not form a separate, isolated community from the rest of the population. They participate in the same sound changes in which non-favela residents participate, namely the fronting and raising of vowels

before word final /S/ and the diphthongization of open /a/ before alveolars. This suggests that they are more integrated linguistically into the community than African Americans are to white vernaculars in many urban centers in the United States, a fact that Labov & Harris (1986) attribute to widespread racial segregation in housing, jobs, and education. If de facto segregation were the main factor, however, one would expect to see a similar situation in cities like Rio de Janeiro, where most of the lower class live in communities that are seemingly isolated from middle class communities. Few members of the middle class in Rio have ever ventured into a favela, partly out of fear, but also perhaps due to a sense of disgrace that they feel the favelas bring to the city. Even some public spaces are segregated in Rio; for example, certain beaches are widely known as being beaches that favela residents use.

However, spacial segregation may not be enough to produce more than one linguistic community in a single urban area. Social segregation combined with a strong sense of identity within the discriminated group may be a more important factor. The interviews with favela residents in this study did not reveal much evidence of a sense of identity within their community. This may be due to the favela's proximity to a large middle and upper class neighborhood in Niterói. Residents of the favela view their community as an extension of the surrounding neighborhood. The residents are fully aware of the stigma associated to living in a favela, which explains why they never use the word *favela* themselves. This does not exclude the possibility that other favelas in Rio are more socially segregated and do have a strong sense of identity, but more extensive research would be required to explore this possibility.

The results of this study are in contrast to those of De Oliveira (1983), the only other sociolinguistic study in a Brazilian community that uses a multitiered model of social class. De Oliveira found that postvocalic -r deletion appears to be a change in progress led by the lower class, and not the working class or lower middle as

found for most other cases of changes in progress, including the ones this study. He attributed this finding to a difference in the structure of Brazilian society in contrast with industrialized societies like the US and England. While industrialized societies tend to have large working and middle classes, the lower class is the largest class in non-industrial or recently industrialized societies like Brazil. If it were just a question of which class is the largest in terms of raw numbers, one would expect the lower class to still be predominate today, 30 years after De Oliveira's study (his data was collected in 1977). Even though the working and middle classes have grown considerably since the late 1970s, the lower class is still the largest class in Brazil, as shown in Chapter 2, Tables 2.1 and 2.2.

However, it's important to note that the class structure in Brazil is no longer pyramid-shaped as it was in the late 1970s. According to De Oliveira's research for Belo Horizonte, the lowest class was over twice as large as the second lowest class, while the second lowest was nearly twice the size of the class just above it. These data were based on income, and thus are comparable to those in Table 2.1. Although the data in Table 2.1 are divided in such that a very small ultra low-income class is created (Class E), there are three classes that are roughly the same size in Rio: Class D (24.8%), Class C2 (24.6%), and Class C1 (23.1%). This suggests that Brazil, and Rio in particular, may be transitioning from a recently industrialized nation with a pyramid-shaped class system to a postindustrialized system with large working and middle classes. In fact, using the occupation-based class scheme in Table 2.2, the central classes of skilled manual workers, petit bourgeosie, and non-manual routine workers, which correspond to the working and middle classes in this study, are already larger than the lower class when combined. This was not the case at the time of De Oliveira's study. Thus even though the lower class is still the single largest class in Brazil, the working and middle classes have grown enough that they nearly rival

the lower class in terms of size. Thus it is now possible that linguistic changes can originate in these classes as well. This may explain why a curvilinear relationship with social class was found for the fronting and raising of checked /a/ and /ai/, but not for the diphthongization of open /a/ in Chapter 5, Sections 5.1.1.2 and 5.1.2.2. While the working class appers to be leading the change in the fronting and raising of checked /a/ and /ai/, the lower class appears to be ahead in the diphthongization of open /a/. Thus linguistic changes that originate in either lower or working class are capable of spreading to the rest of the society.

Labov (2001) attributes the curvilinear pattern to the working class's centrality in local activity, local interaction, and local prestige. Which classes are central in these regards, however, may vary from one society to another, and even from one generation to another in societies undergoing rapid socioeconomic transformations like those in the developing world. In societies like Brazil, where there is a large disparity both economically and culturally between the upper and lower classes, it is possible that more than one class may be central in local activity, interaction, and prestige. The working class often shows up as the leaders of linguistic change in urban societies because they have frequent and sustained interactions with members of both lower and middle classes; thus, their influence is the most widespread. However, extreme social stratification as in Rio may result in segments of the society not participating in certain linguistic changes, similar to the case of African Americans in U.S. cities, and perhaps participating in other changes that do not affect the rest of the society. Although no evidence for this was found in this study, nor in De Oliveira's, it cannot be ruled out for several reasons. First, only two linguistic variables were examined; ideally one would need to examine several variables to test this hypothesis. In addition, such a distribution is unlikely to show up in a study of thirty-six speakers. While a study of this size is large enough to show that a curvilinear pat-

ter exists, there are not enough speakers to make finer grained distinctions such as upper working, lower middle, etc. Most importantly, however, the lowest class in the society, both in this study and in De Oliveira's, remains understudied. De Oliveira faced the same problem encountered in this study: members of the lower class are the most difficult to access. Researchers cannot simply walk into a favela looking for participants; not only would this be dangerous for the researcher, the request would likely be greeted with extreme skepticism. What is needed to resolve this problem is a more anthropological approach, in which the researcher first gains the trust of the participants through a longer period of interaction. Of course, this involves time and resources that are typically more difficult to obtain. But, it is a necessary next step in this type of research, both for understanding the relationship between language and social class, and investigating the linguistic consequences of social segregation and local identity in the urban area.

This study is best thought of as a study of the newly developed central classes. With about quarter of Rio de Janeiro (1.5 million people) making $200 a month or less in 2008 (based on Table 2.1), one cannot speak of merely a lower class, but rather the lower *classes*. The participants labeled as "lower class" in this study likely represent the more prosperous and influential members of the lower class. It is likely that the majority remain unrepresented. Thus while further research is needed to gain a complete understanding of the social situation, the results from the available data are revealing. That the data on language variation in Chapter 5 already resembles those of developed countries, with females from the working and middle classes leading linguistic changes, is in itself an important finding. It suggests that societal change and language change are tightly connected; as the working and middle classes grow, they immediately become prominent in their roles as leaders of linguistic change.

The pattern found for speaker sex, with women leading both the fronting and

raising of checked /a/ and /ai/ and the diphthongization of open /a/, is consistent with data from other societies, in which linguistic changes from below the level of consciousness tend to be led by women (Labov, 2001). It is interesting to note that although speakers are fully aware of the diphthongization of checked /a/ and /ai/, they are not aware of the fronting and raising of these vowels. This is clearly illustrated in the perceptual data presented in Chapter 6. Even though for many speakers the *mas* vowel is more fronted and or raised than the *mais* vowel, listeners rely more on vowel length and the degree of diphthongization when attempting to distinguish these words (see Table 6.7). The change from monophthong to diphthong for checked /a/ is nearly complete in Rio, with only one (Luisa) out of thirty-six speakers showing any significant difference between the checked /a/ an /ai/ glides. Nonetheless, the fronting and raising of these vowels, a change that is in many ways related to diphthongization (see the discussion of undershoot in Section 5.1.3) remains below the level of consciousness and shows the expected correlation with speaker sex.

Sociolinguistic research in lesser studied languages and societies is important for testing existing theories on language variation and change and increasing our understanding of how social factors interact in different societies. Although Portuguese is hardly an understudied language, and many language variation studies have been conducted in Brazil, few of them deal directly with class as a social factor, as shown in Chapter 2. As countries like Brazil continue to grow economically, their class structures increasingly look like the ones in developed countries, with most members belonging to the working and middle classes. These societies not only provide a means of testing theories of language variation and change, they provide a way of examining how rapid social and economic change affects linguistic variation and change.

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Appendix A

Vowel Charts

This appendix includes vowel charts for all 36 speakers in this study. For convenience, the sex, age, and social class of each speaker is given in the caption. The vowels /a/ and /ai/ are shown for all speakers; /o/, /ɔ/, and /oi/ are shown only for those speakers who produced sufficient tokens of these vowels. The onsets of each vowel are indicated by large circles, while offsets are indicated by small circles, with lines connecting the two. The positions of the circles reflect the average F1 and F2 values. For the onsets, the height of the circle is the standard deviation of the F1 values, and the width of the circle is the standard deviation of the F2 values. This gives an indication of the variability of the data without making the charts look too overcrowded. Offsets that fall within the circle created by the onset are omitted; these vowels can be considered the most monophthongal. For /ɔ/, /o/, and /oi/, the symbol # indicates a checked vowel; otherwise they are open.

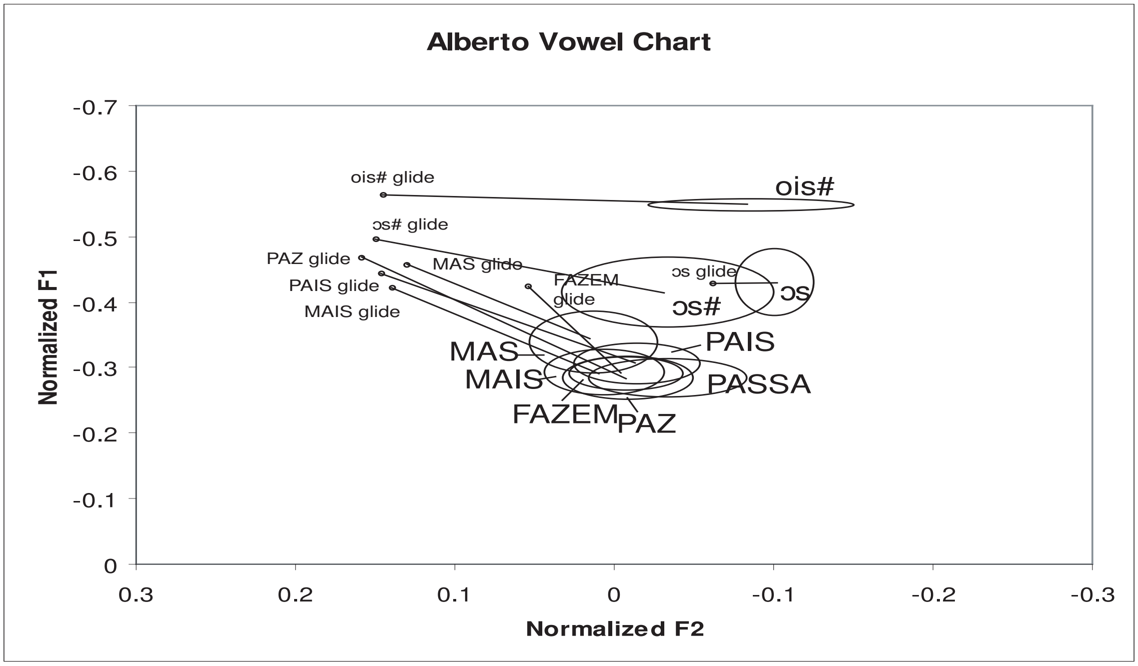

Figure A.1 : Vowel chart for Alberto (M, 40, Working).

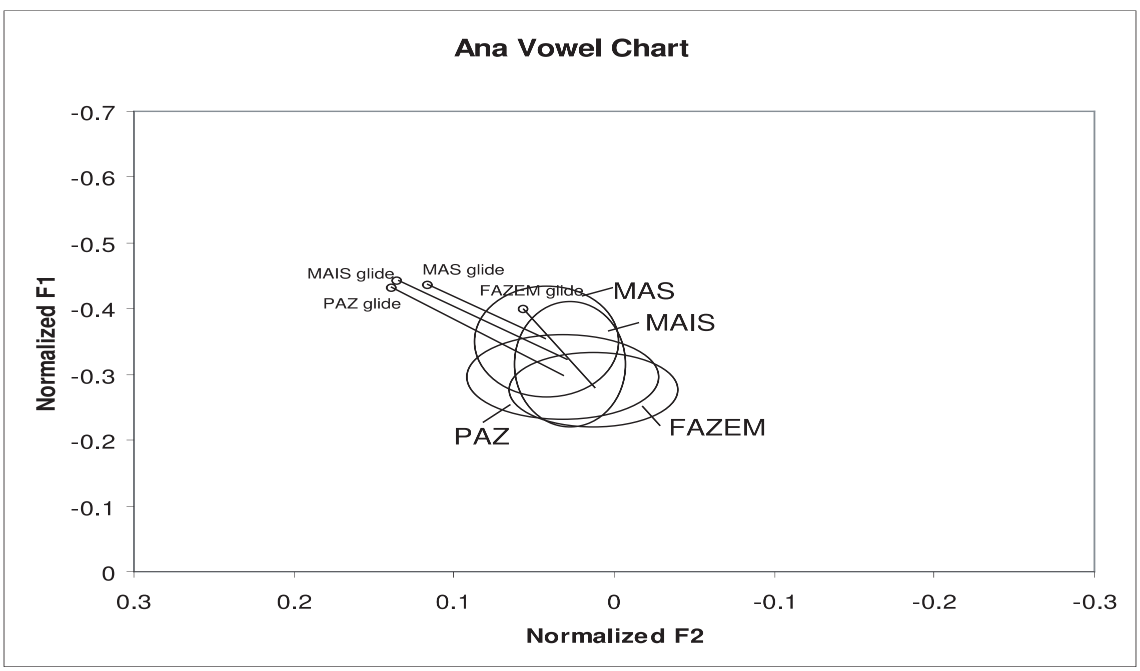

Figure A.2 : Vowel chart for Ana (F, 25, Middle).

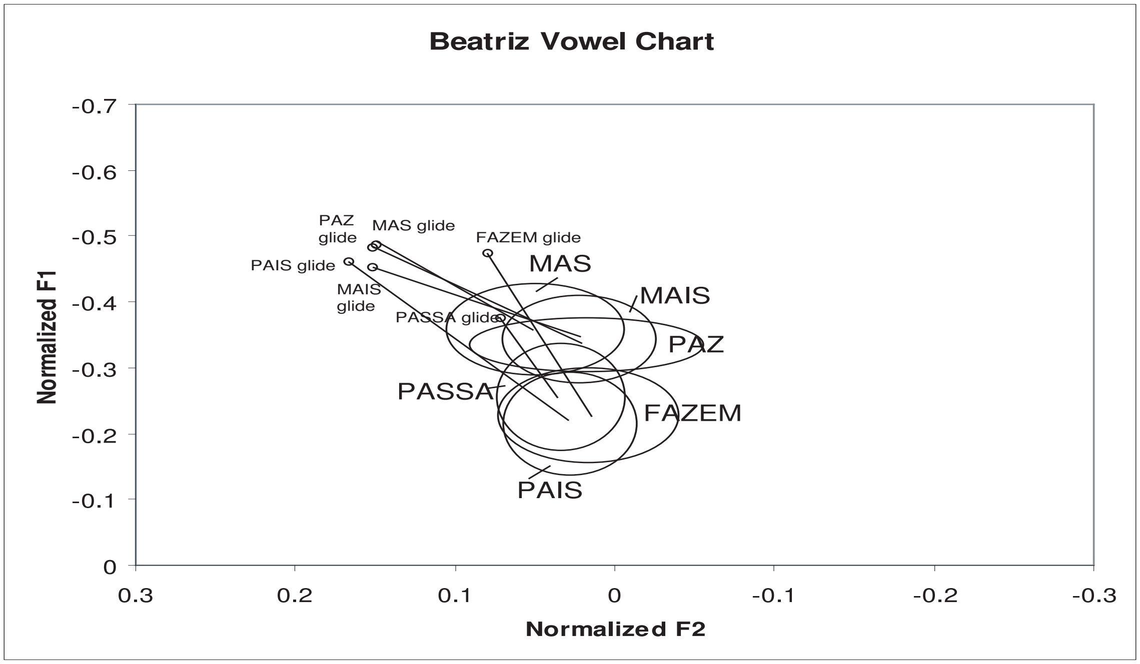

Figure A.3 : Vowel chart for Beatriz (F, 40, Lower).

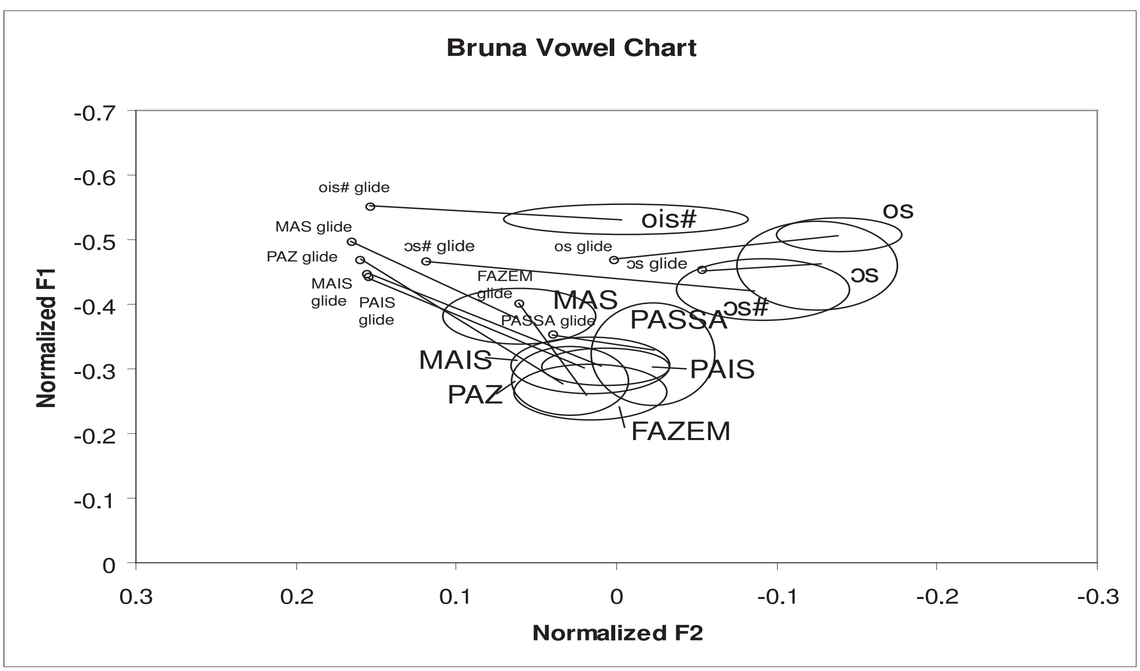

Figure A.4 : Vowel chart for Bruna (F, 20, Upper).

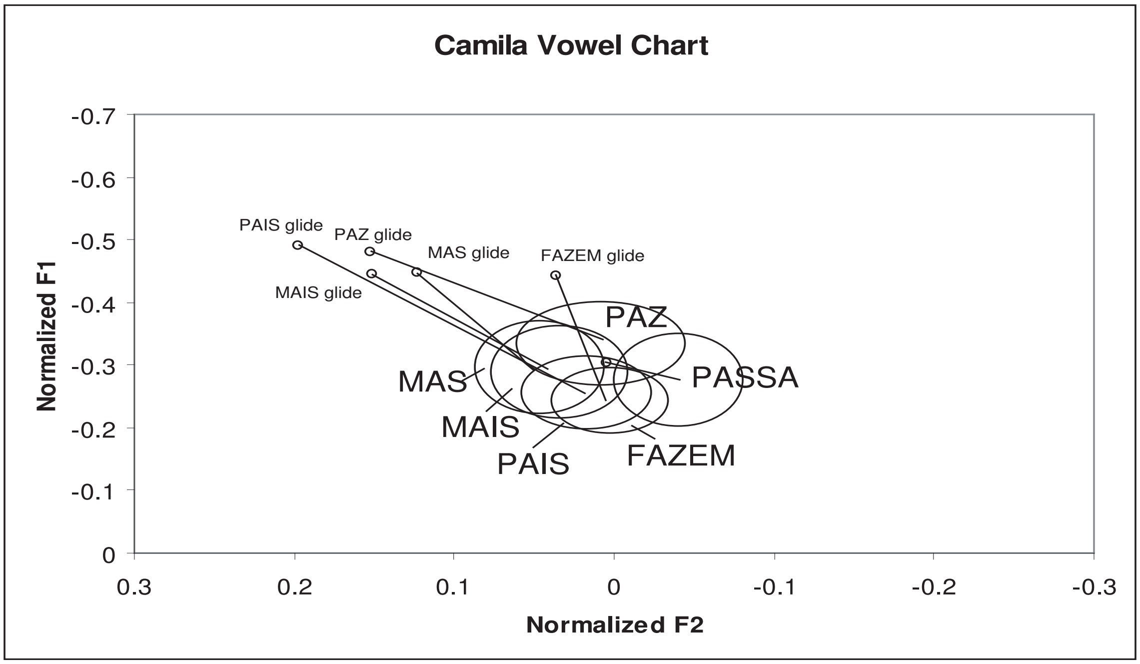

Figure A.5 : Vowel chart for Camila (F, 25, Middle).

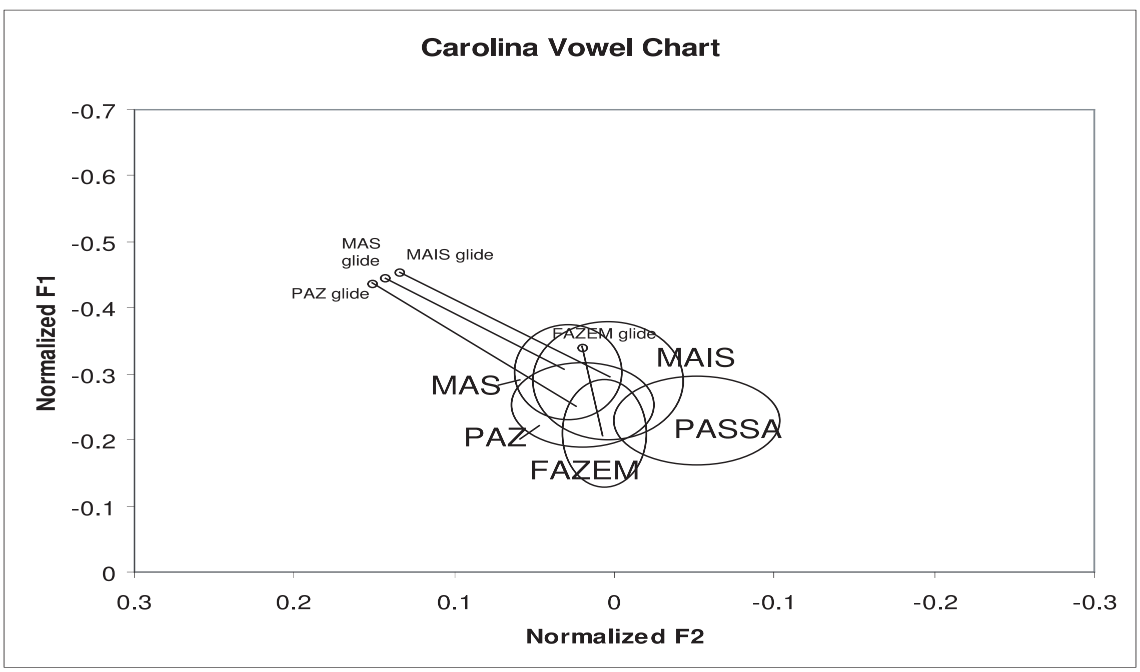

Figure A.6 : Vowel chart for Carolina (F, 25, Middle).

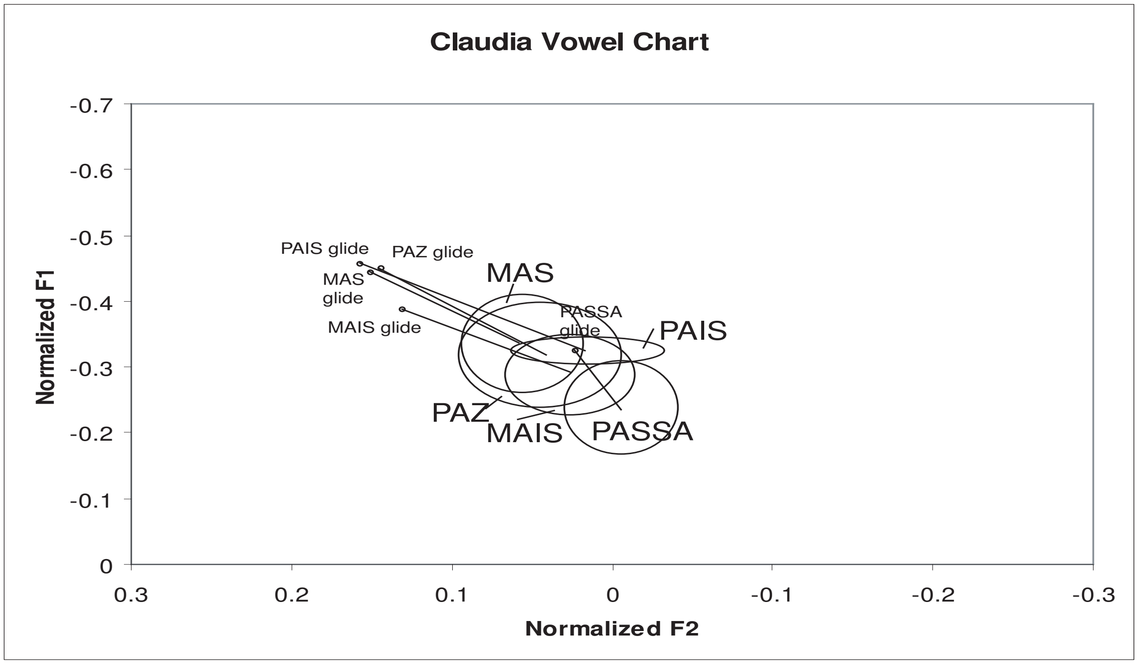

Figure A.7 : Vowel chart for Cláudia (F, 15, Working).

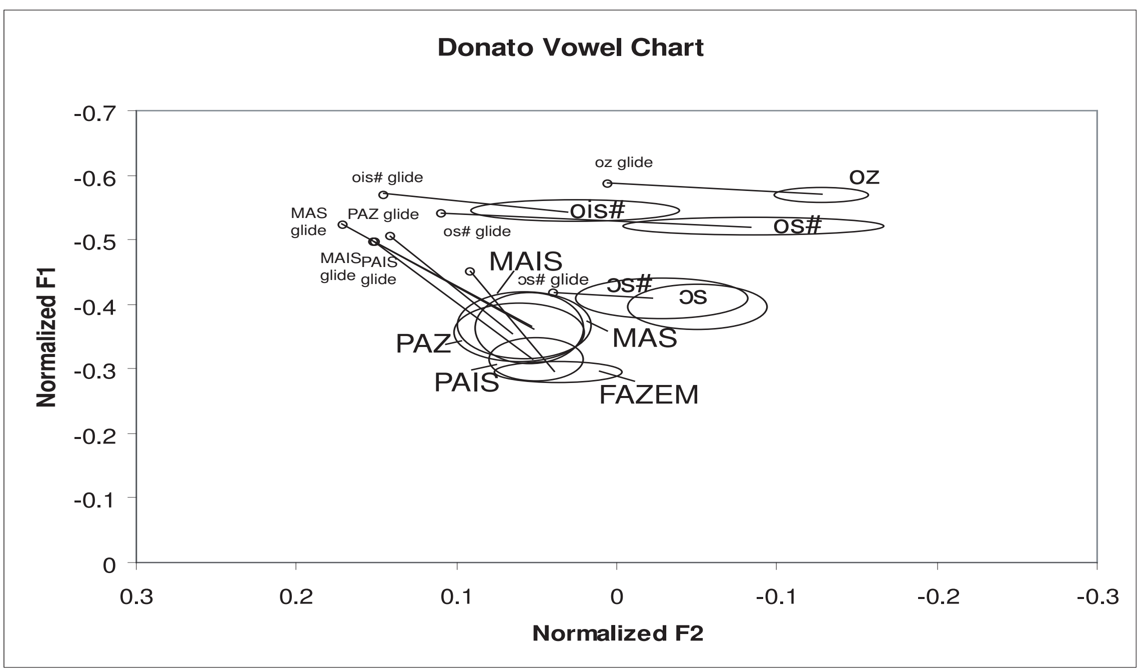

Figure A.8 : Vowel chart for Donato (M, 20, Middle).

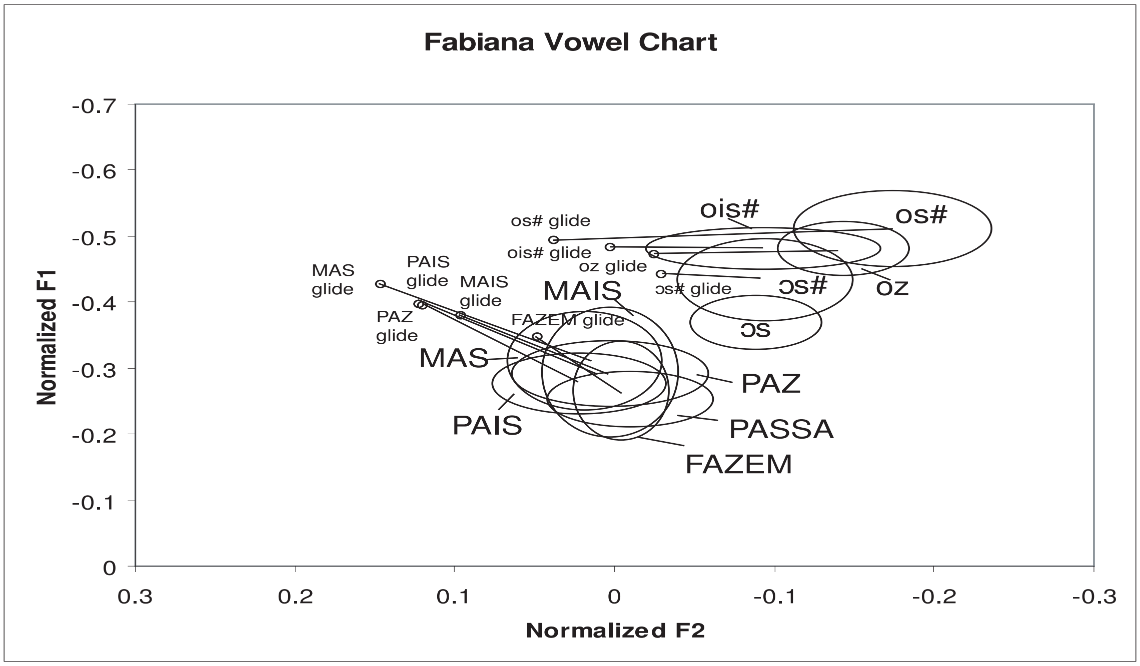

Figure A.9 : Vowel chart for Fabiana (F, 50, Middle).

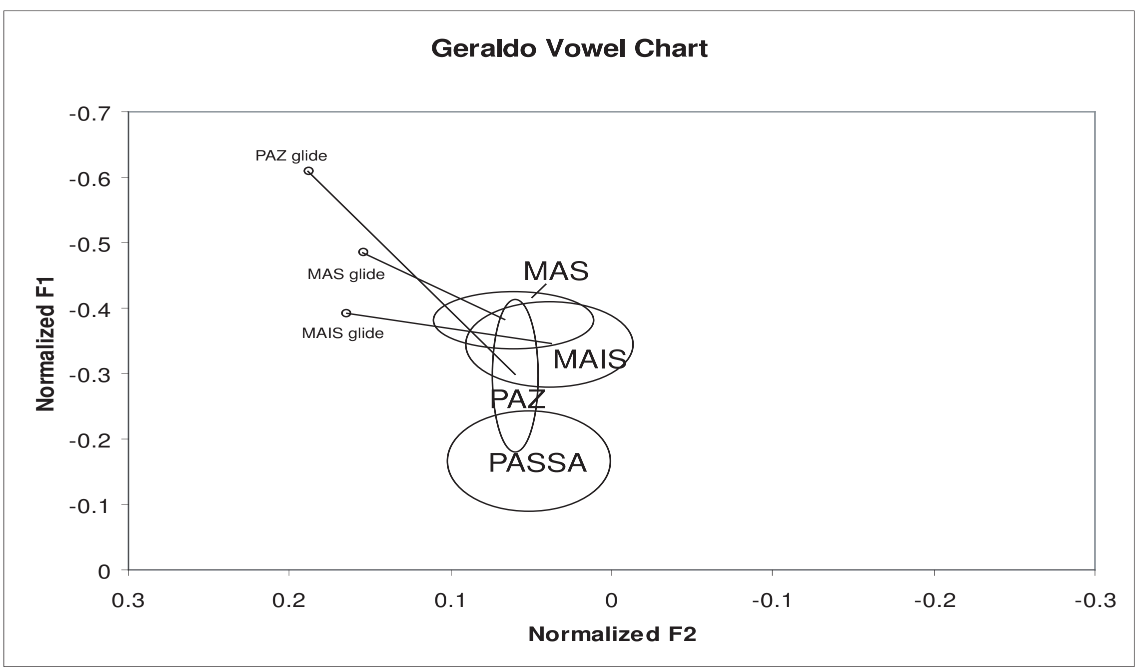

Figure A.10 : Vowel chart for Geraldo (M, 30, Working).

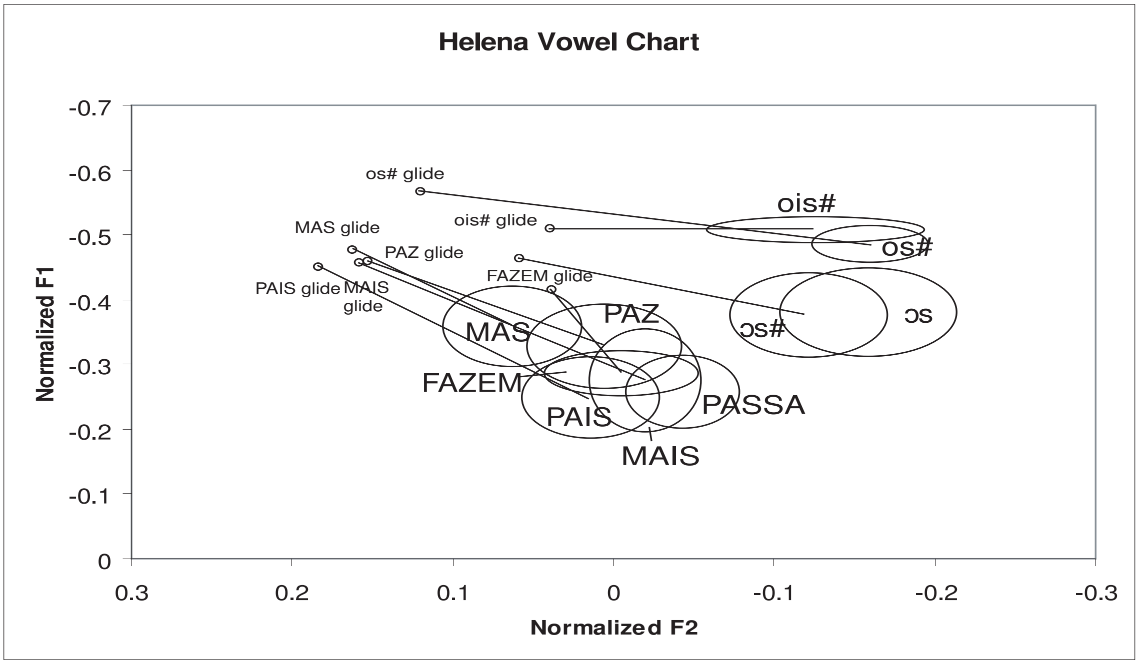

Figure A.11 : Vowel chart for Helena (F, 45, Upper).

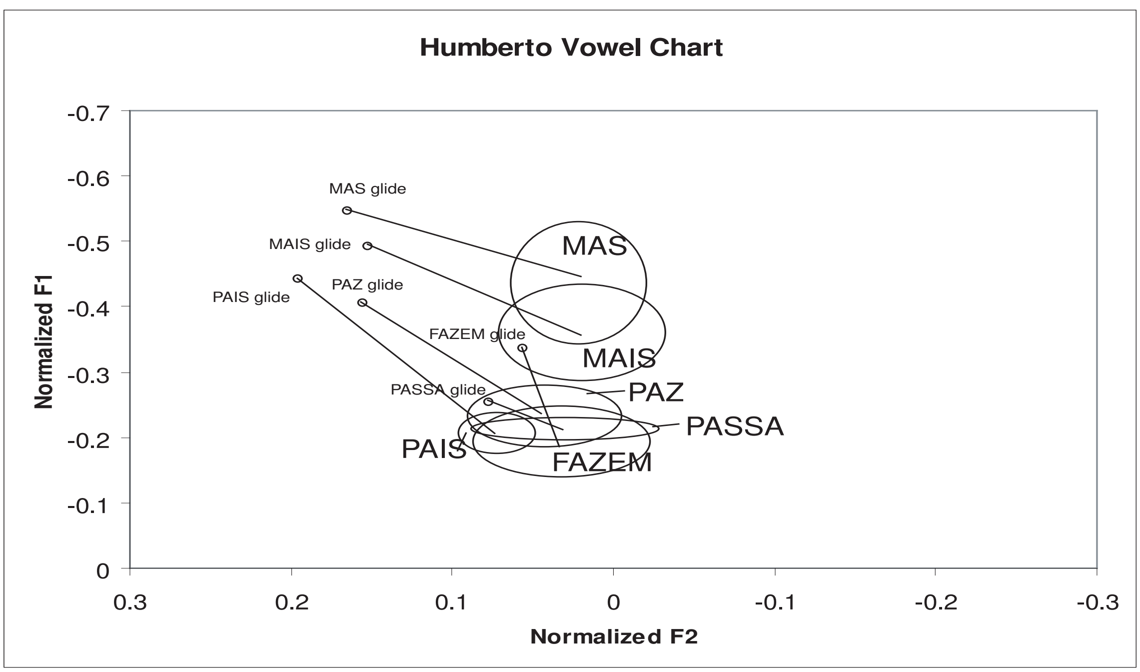

Figure A.12 : Vowel chart for Humberto (M, 30, Working).

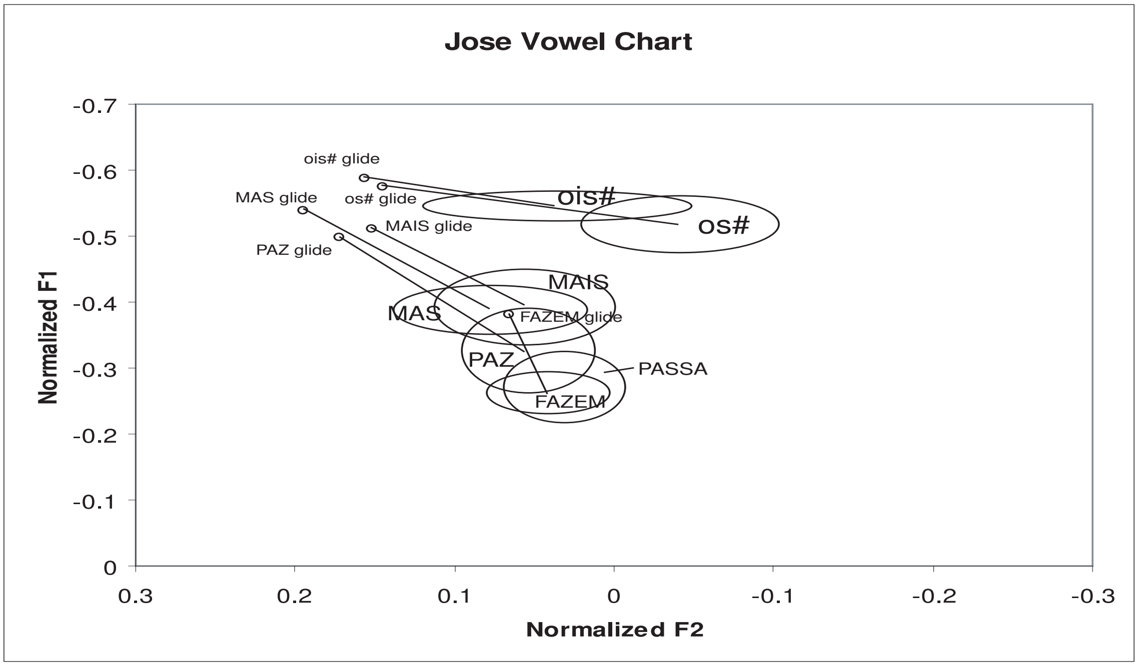

Figure A.13 : Vowel chart for José (M, 20, Working).

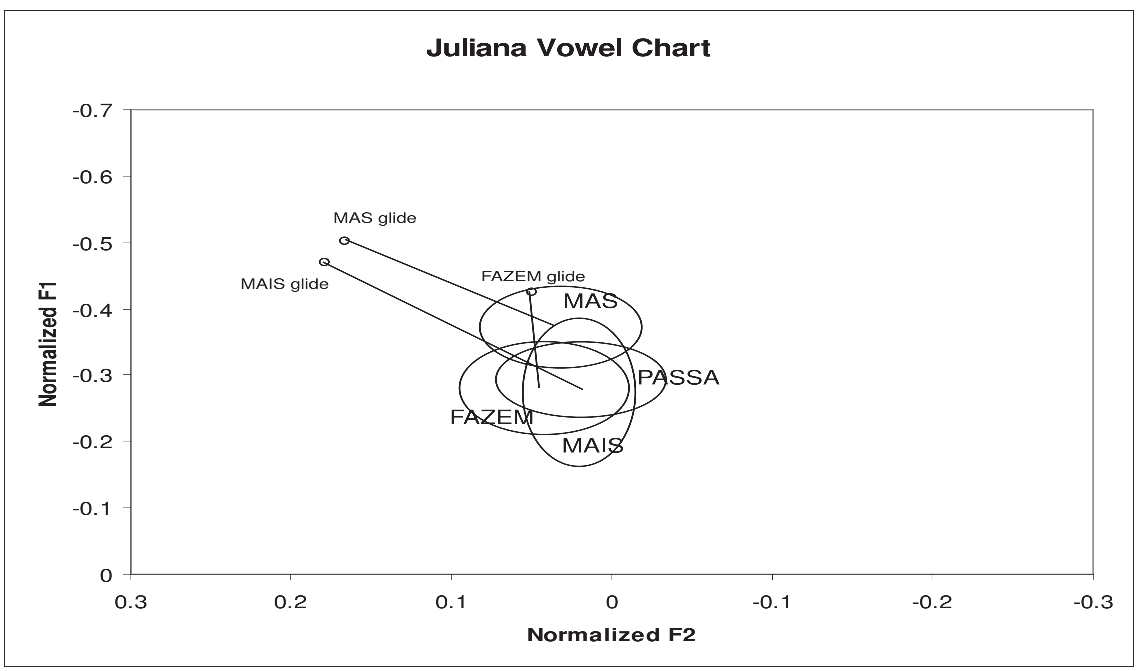

Figure A.14 : Vowel chart for Juliana (F, 50, Lower).

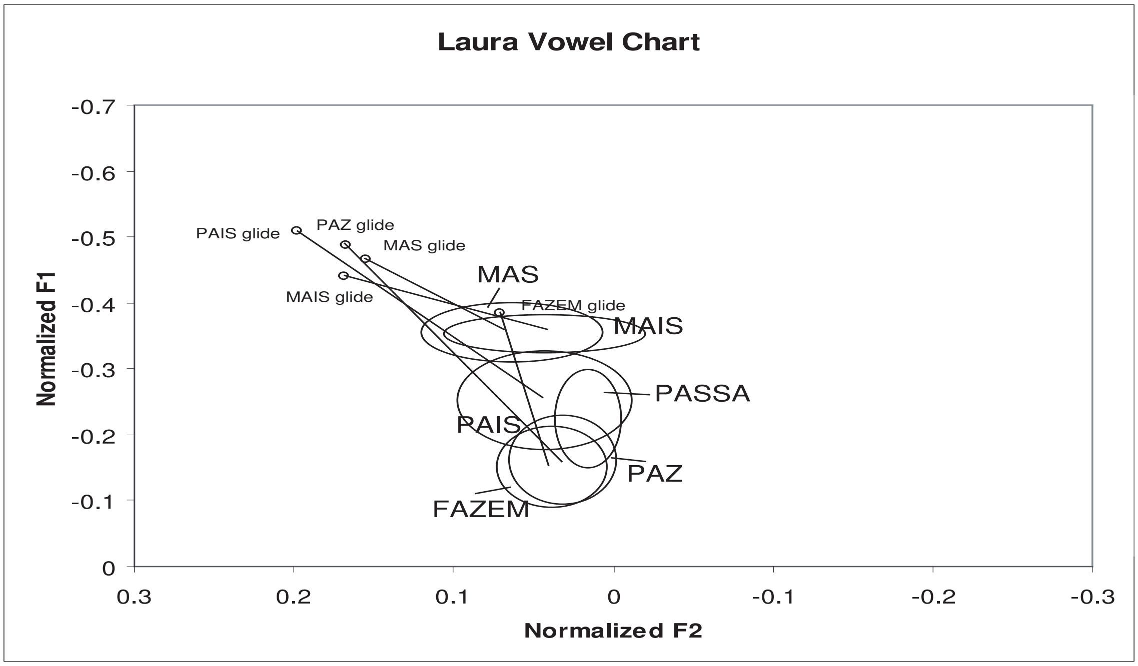

Figure A.15 : Vowel chart for Laura (F, 20, Middle).

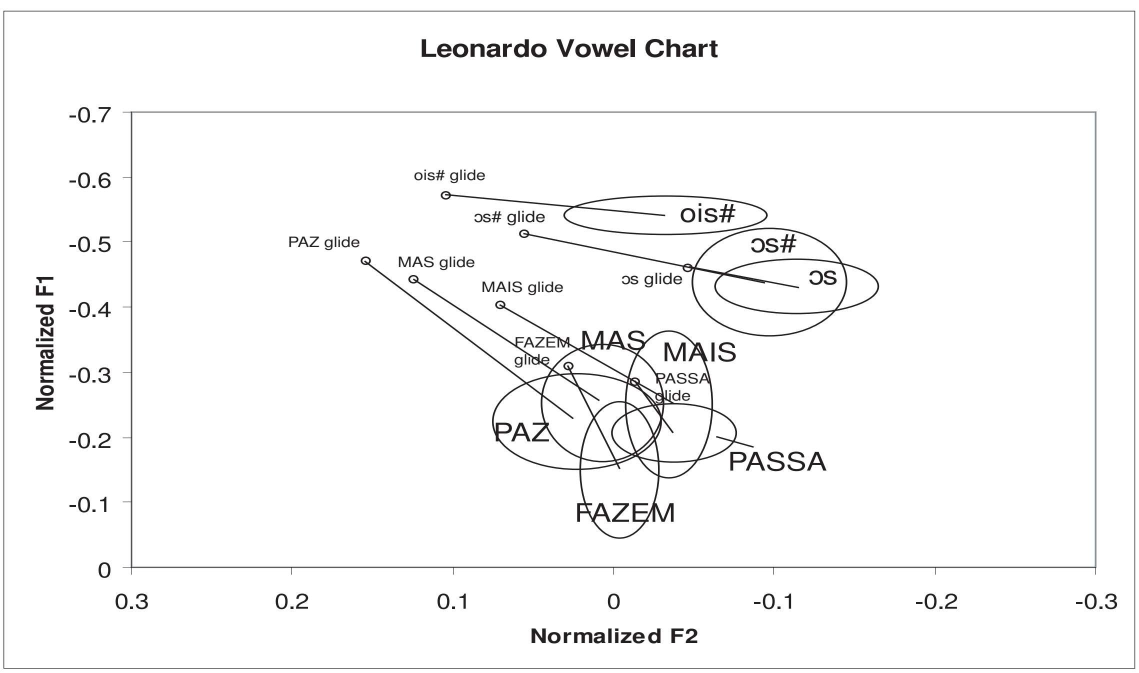

Figure A.16 : Vowel chart for Leonardo (M, 40, Lower).

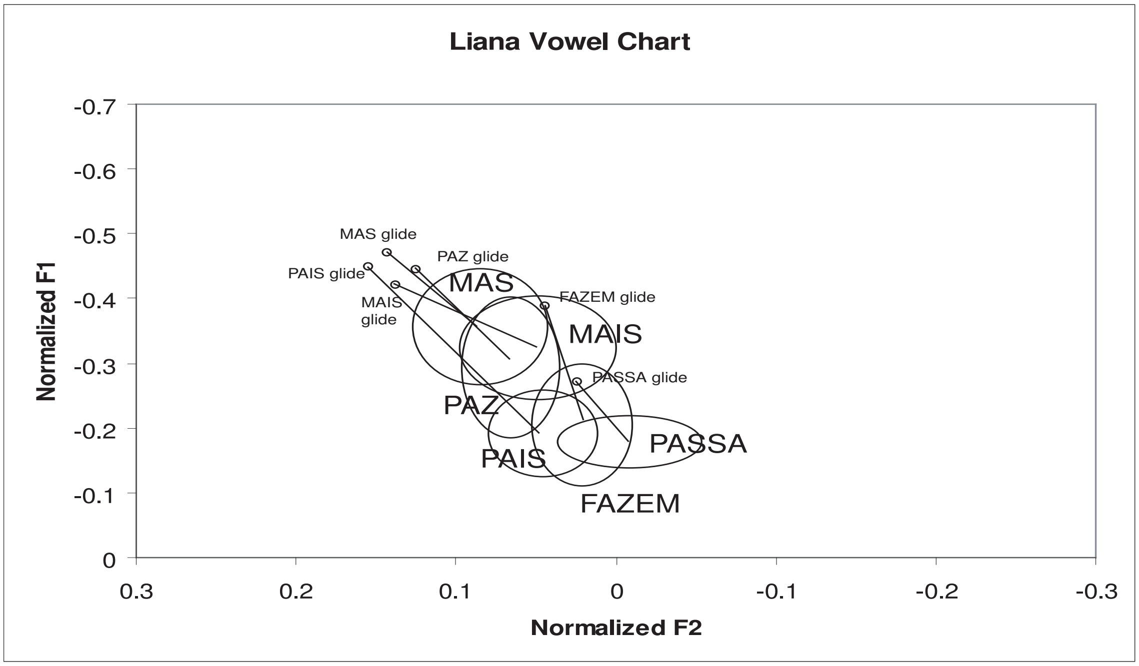

Figure A.17 : Vowel chart for Liana (F, 20, Middle).

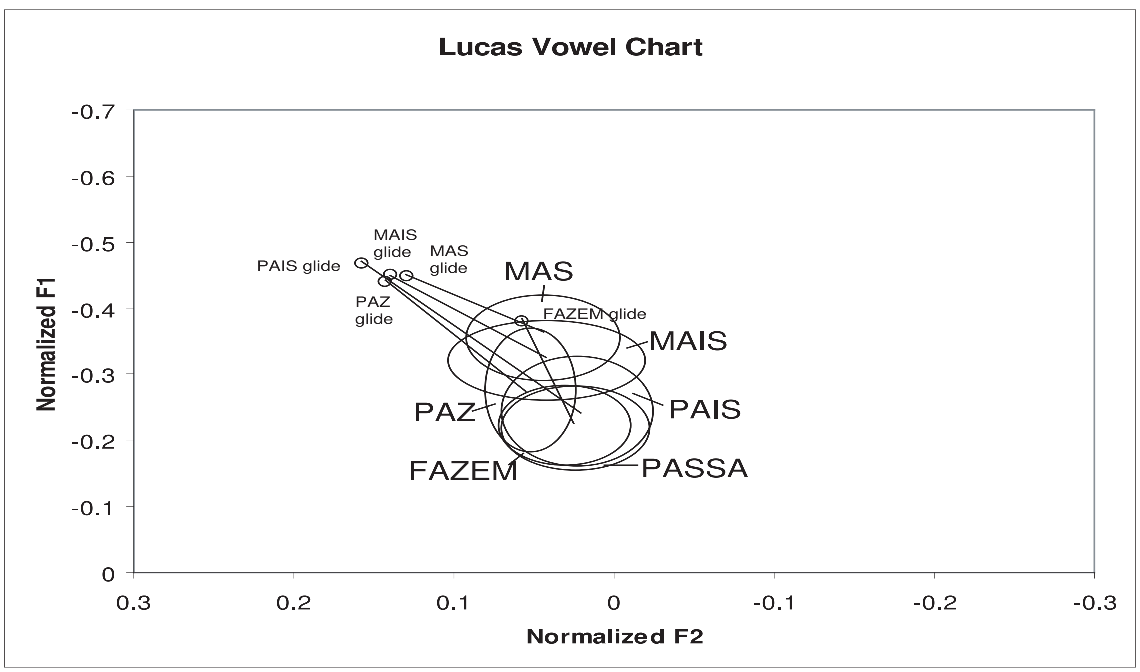

Figure A.18 : Vowel chart for Lucas (M, 20, Middle).

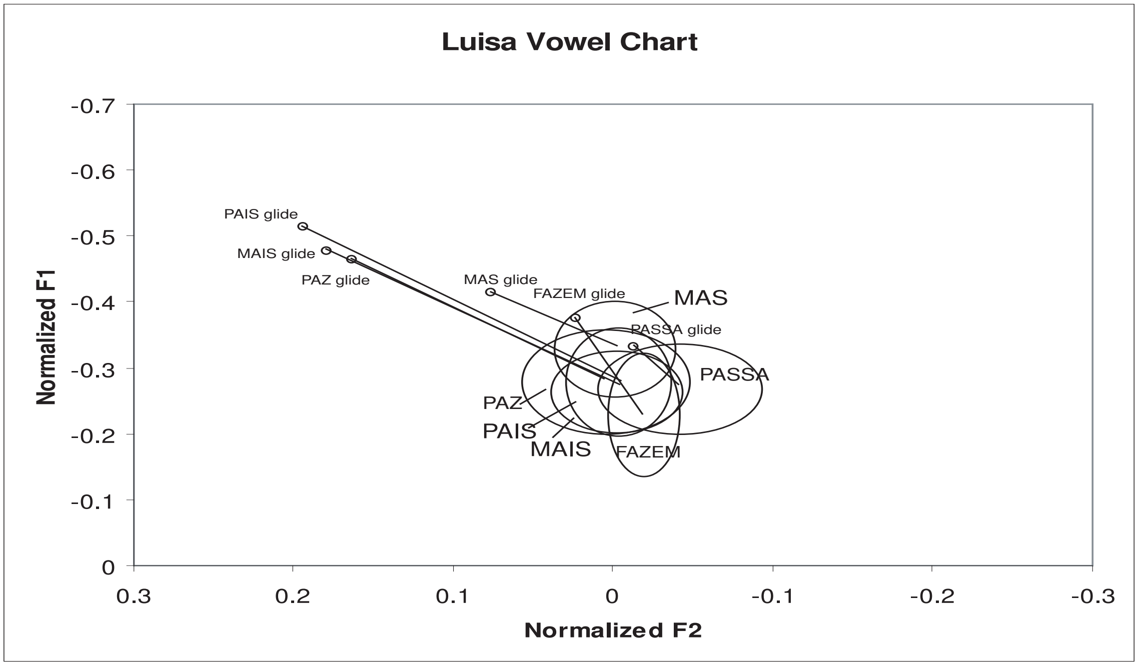

Figure A.19 : Vowel chart for Luisa (F, 50, Middle).

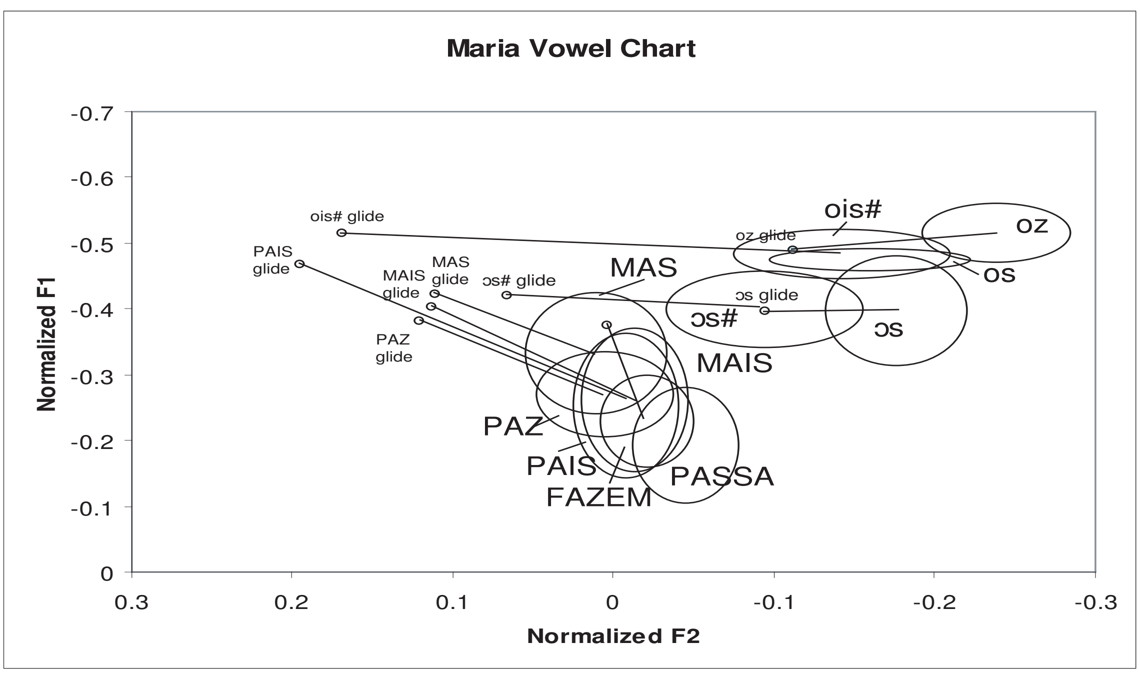

Figure A.20 : Vowel chart for Maria (F, 40, Middle).

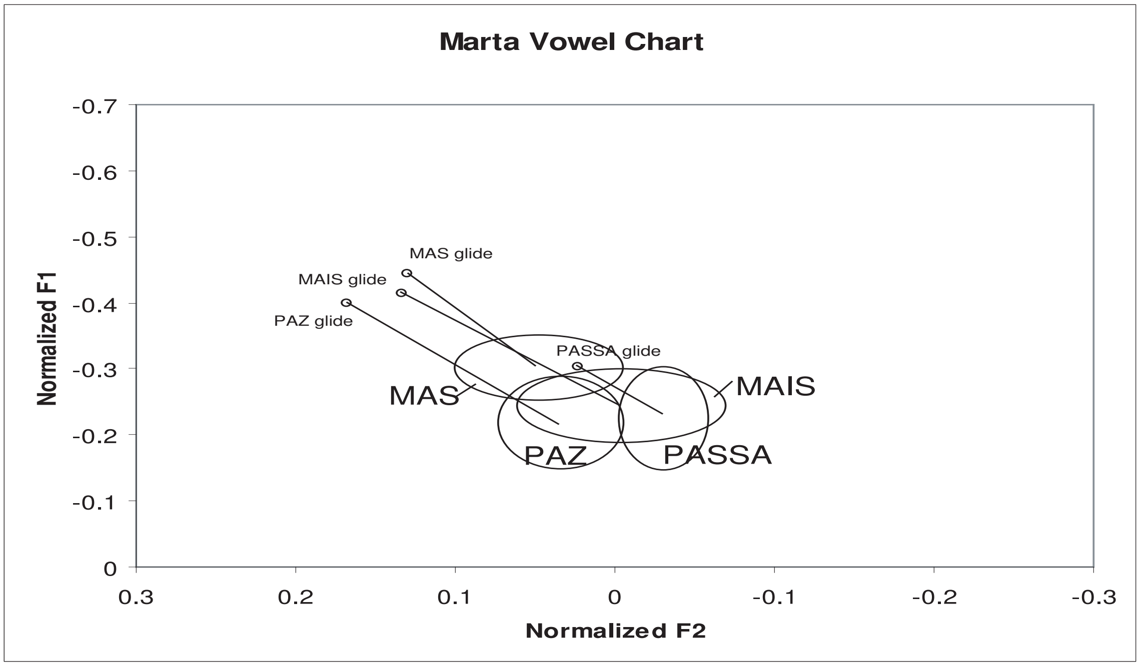

Figure A.21 : Vowel chart for Marta (F, 25, Working).

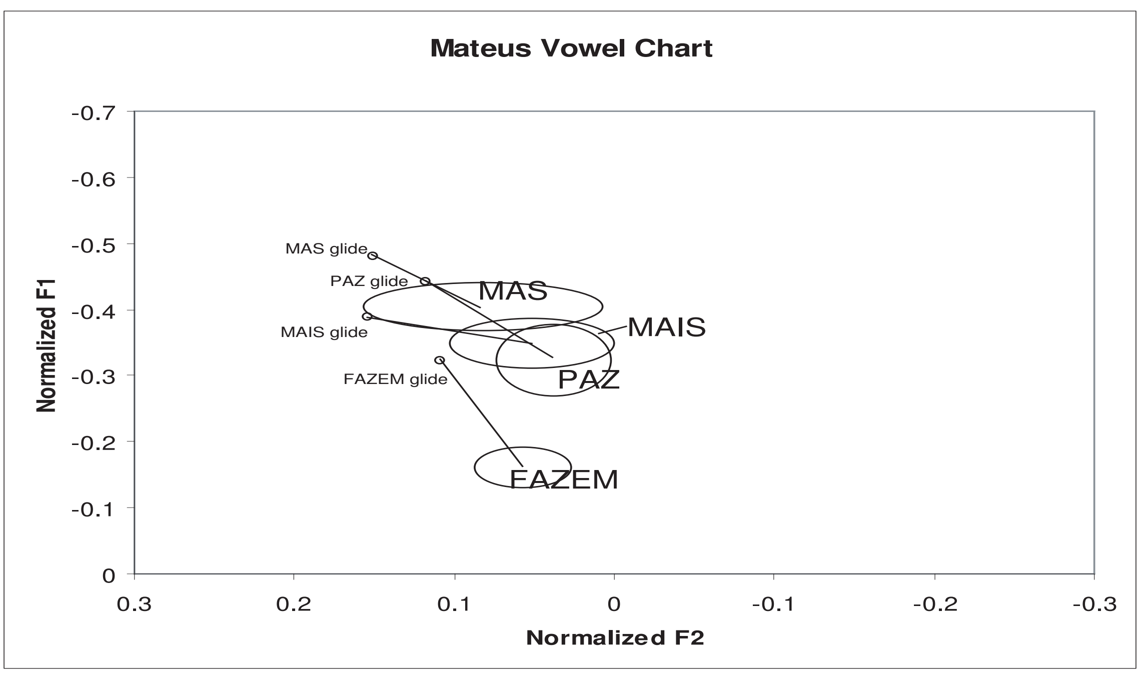

Figure A.22 : Vowel chart for Mateus (M, 25, Middle).

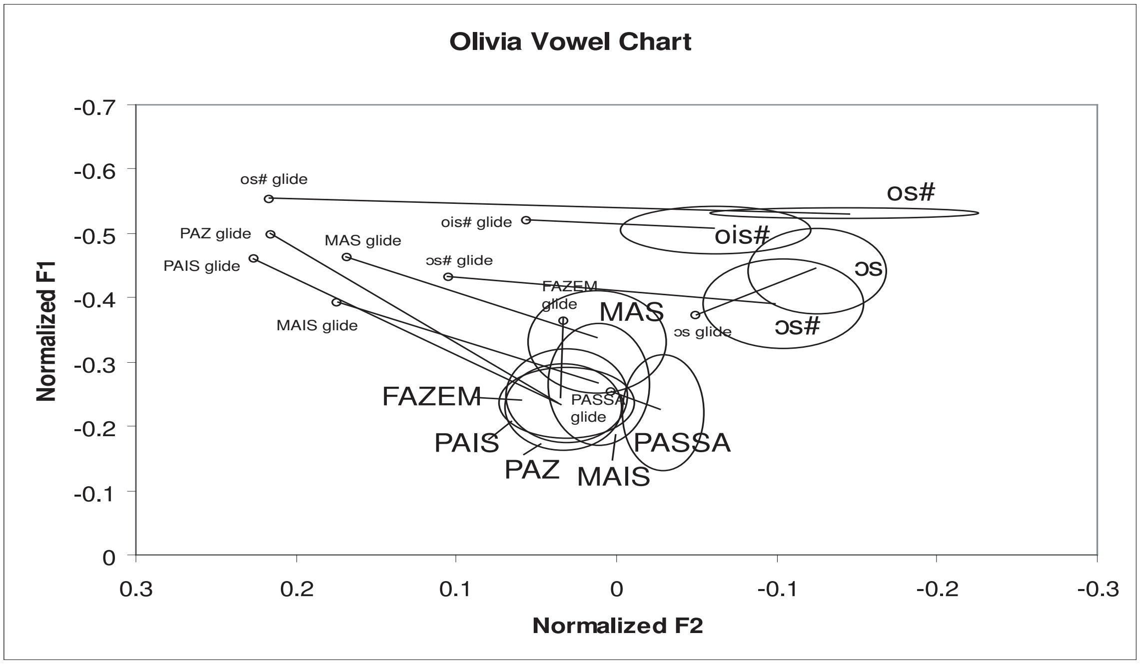

Figure A.23 : Vowel chart for Olívia (F, 40, Middle).

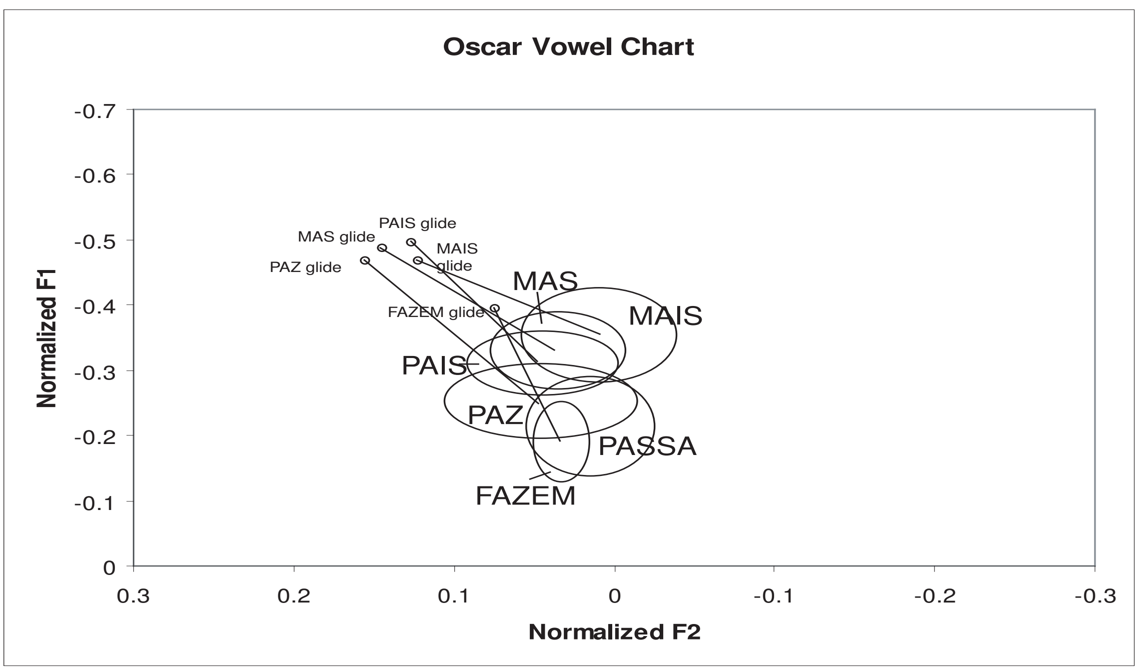

Figure A.24 : Vowel chart for Oscar (M, 20, Working).

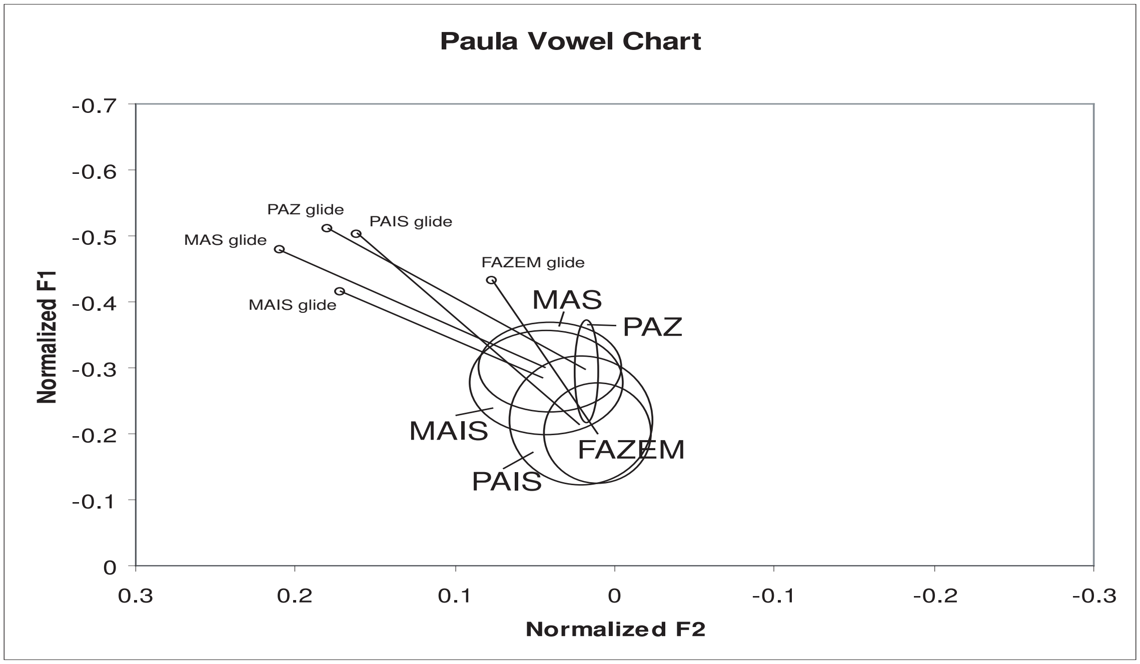

Figure A.25 : Vowel chart for Paula (F, 20, Working).

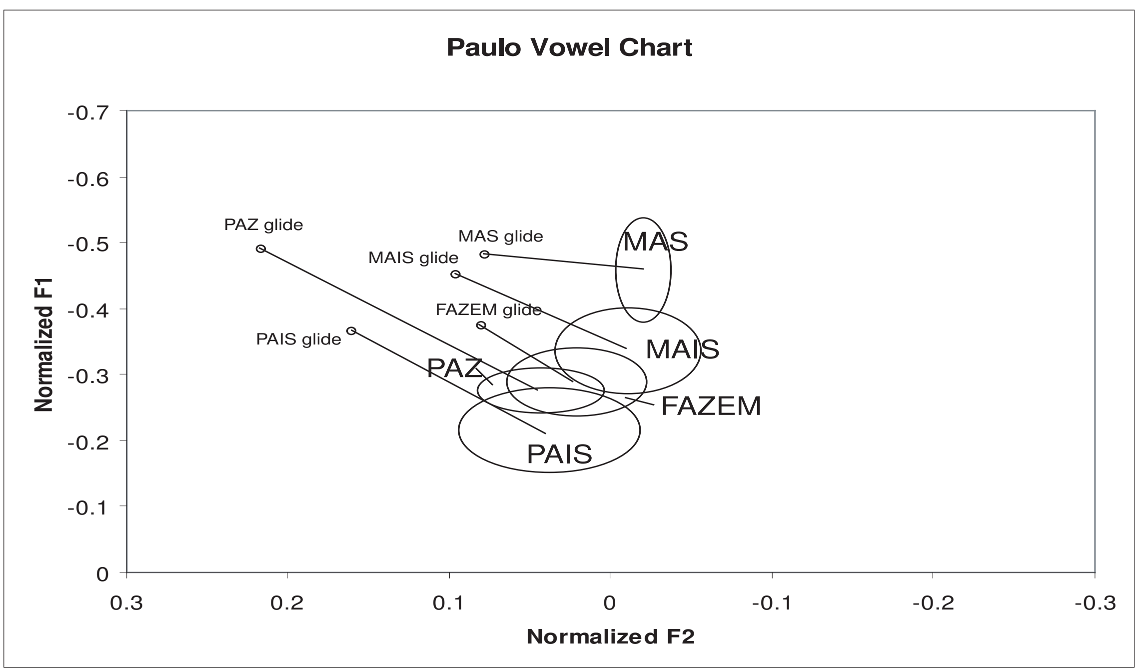

Figure A.26 : Vowel chart for Paulo (M, 40, Working).

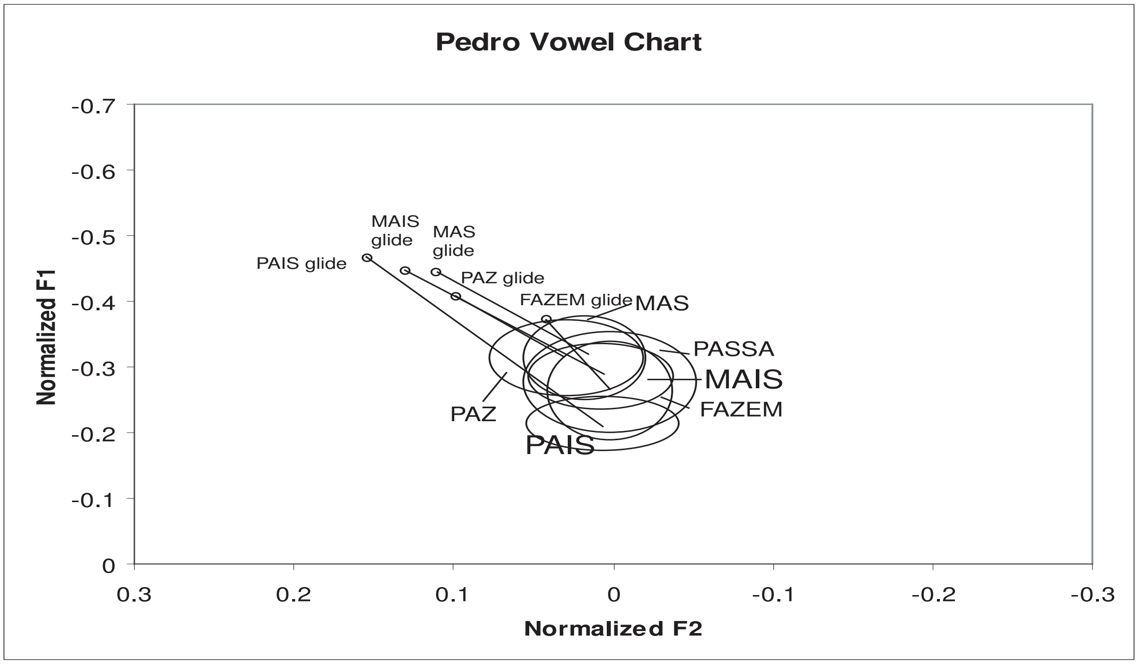

Figure A.27 : Vowel chart for Pedro (M, 25, Middle).

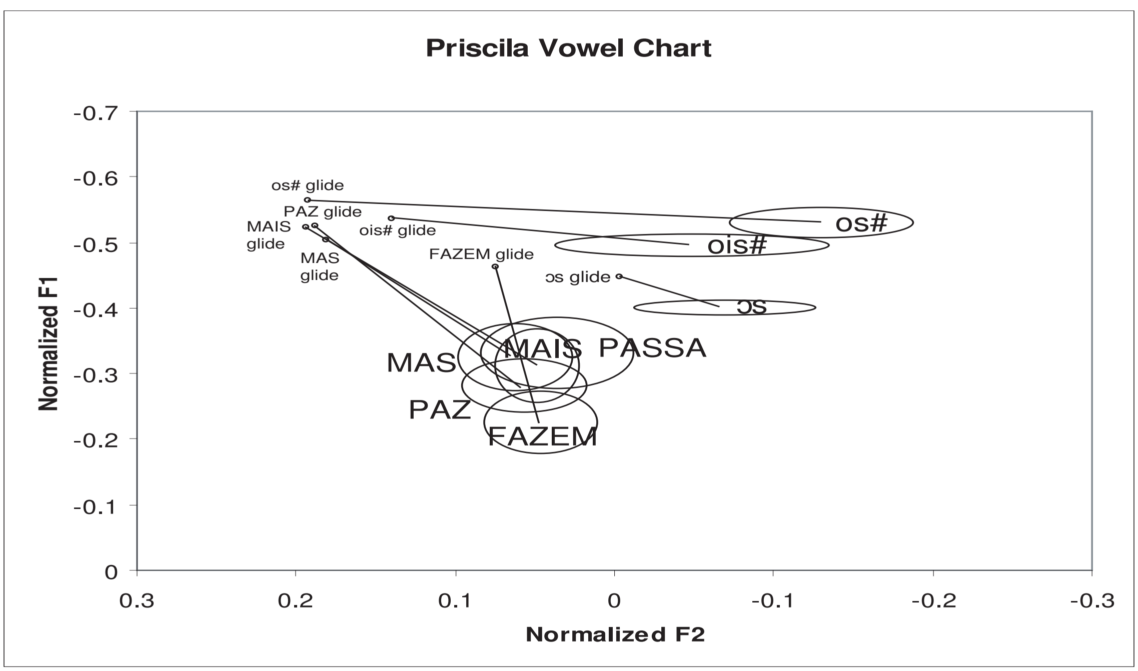

Figure A.28 : Vowel chart for Priscila (F, 20, Working).

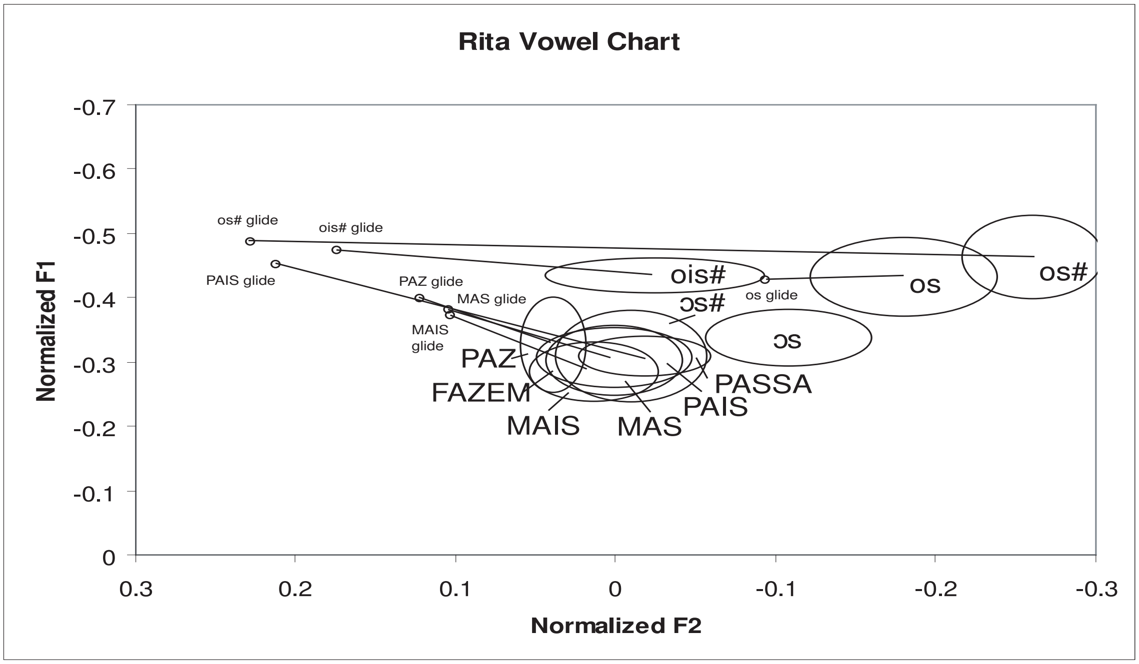

Figure A.29 : Vowel chart for Rita (F, 75, Working).

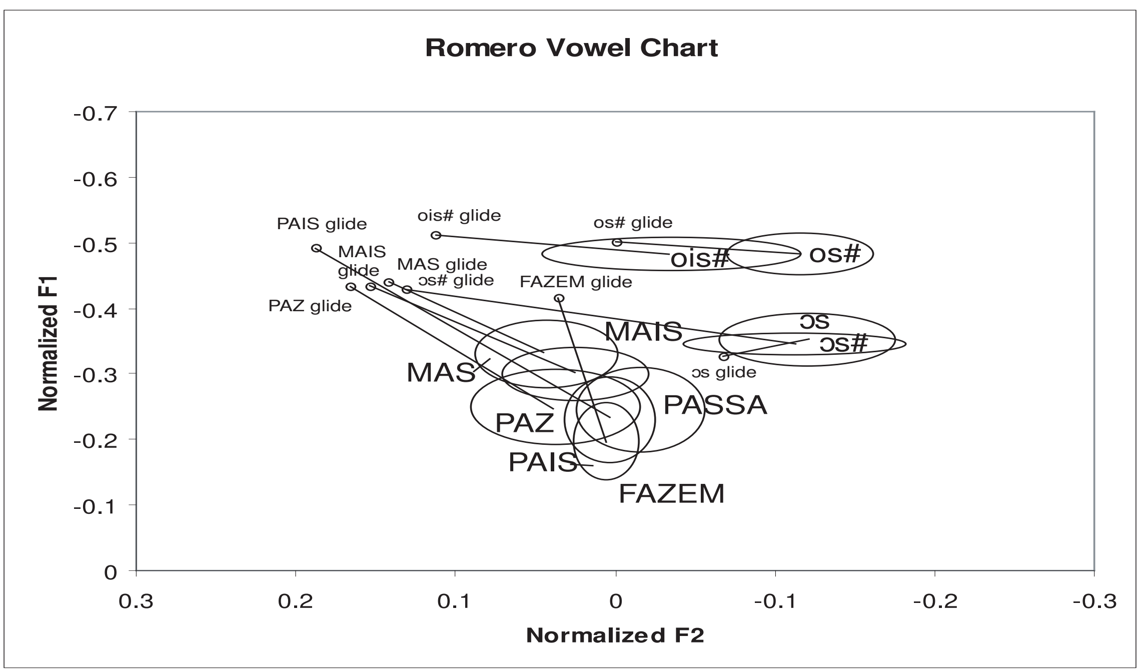

Figure A.30 : Vowel chart for Romero (M, 20, Middle).

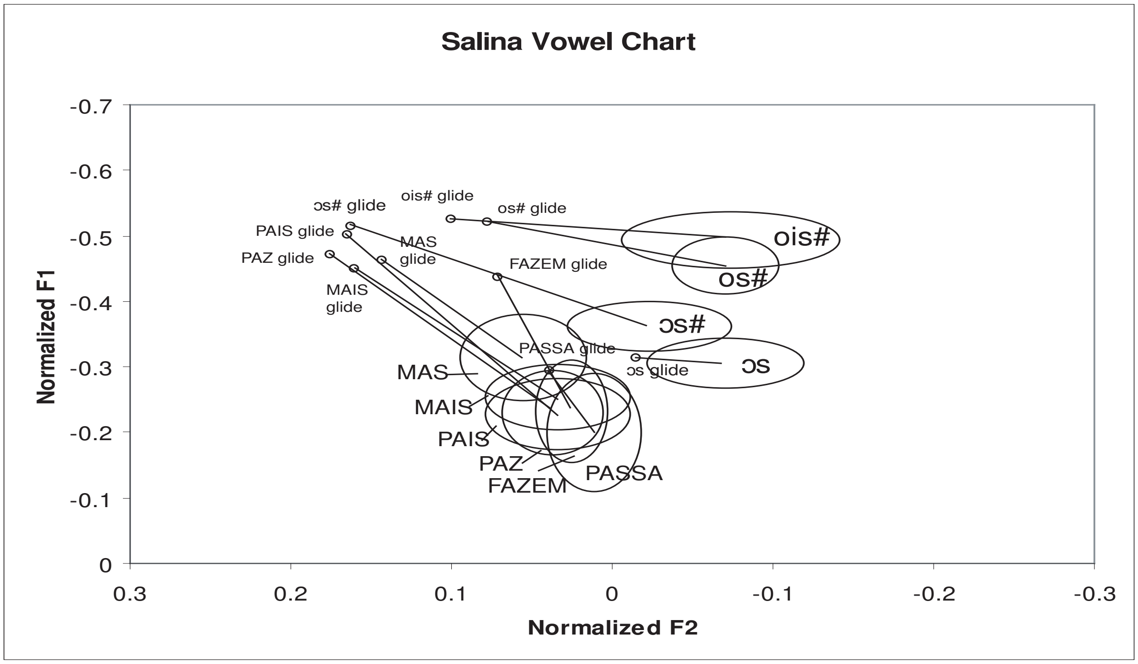

Figure A.31 : Vowel chart for Salina (F, 15, Upper).

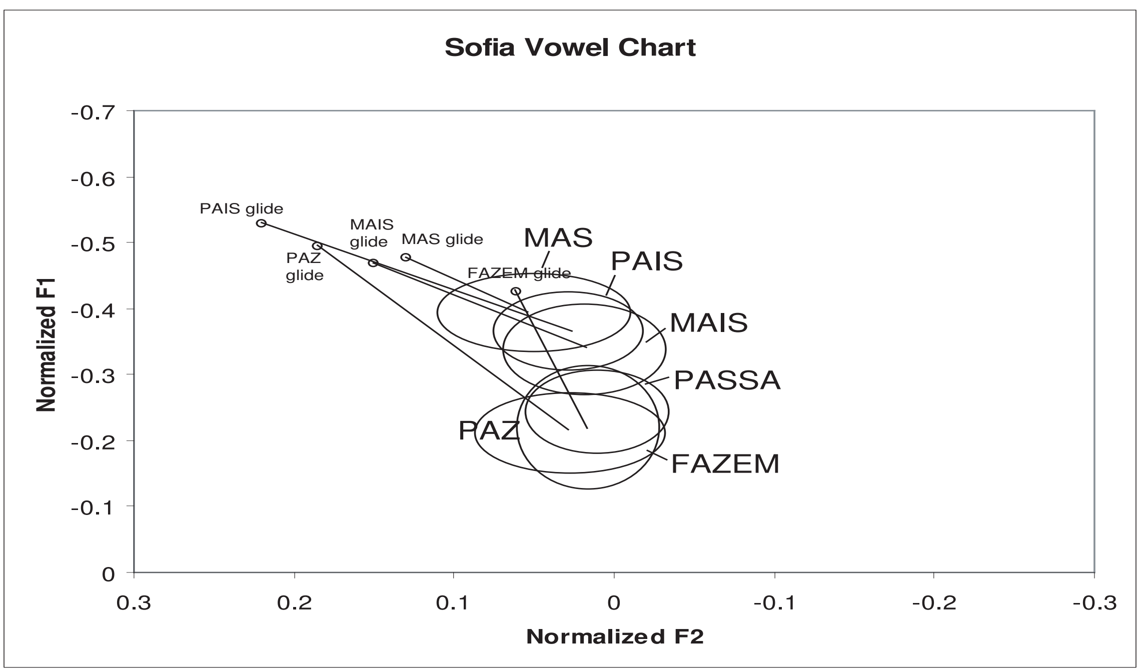

Figure A.32 : Vowel chart for Sofia (F, 35, Middle).

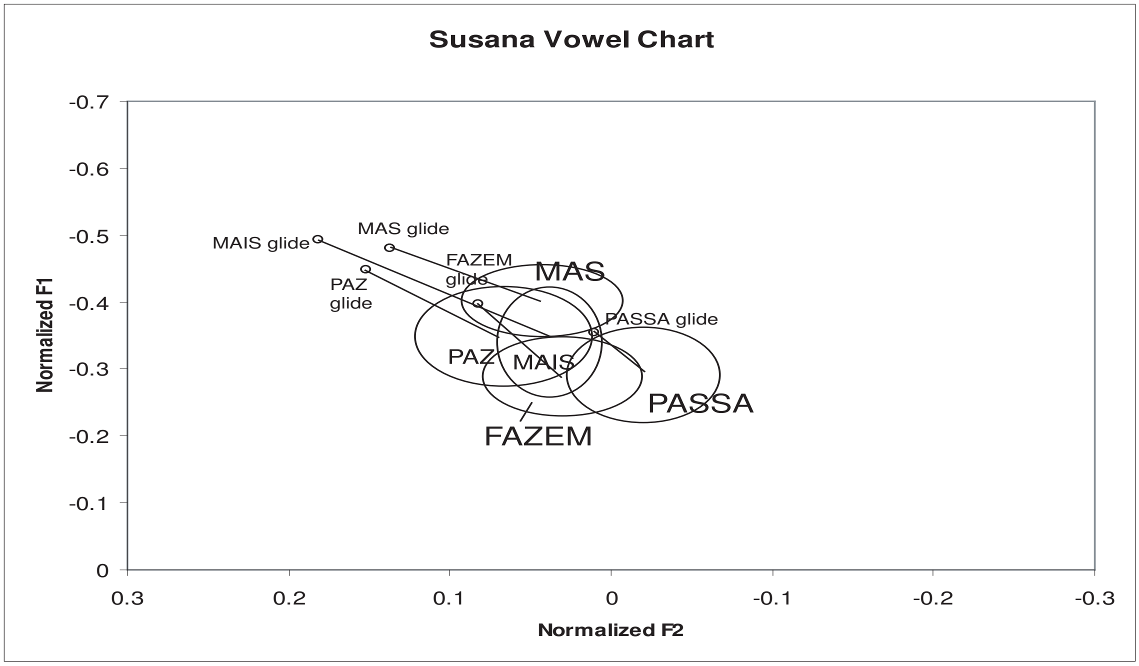

Figure A.33 : Vowel chart for Susana (F, 40, Lower).

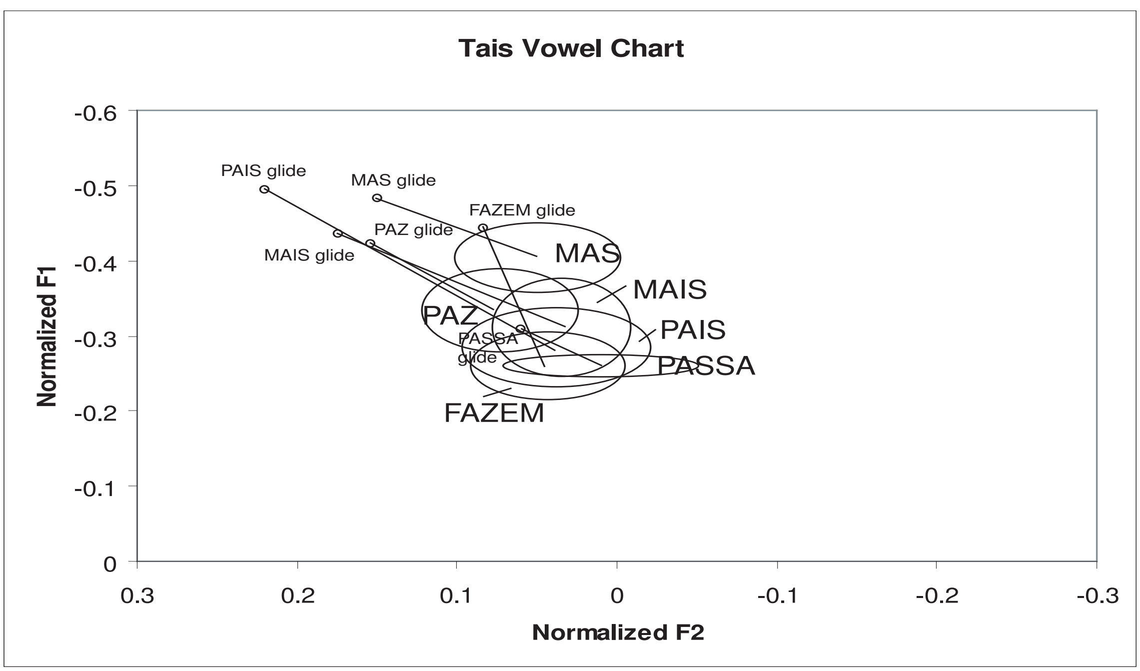

Figure A.34 : Vowel chart for Taís (F, 20, Middle).

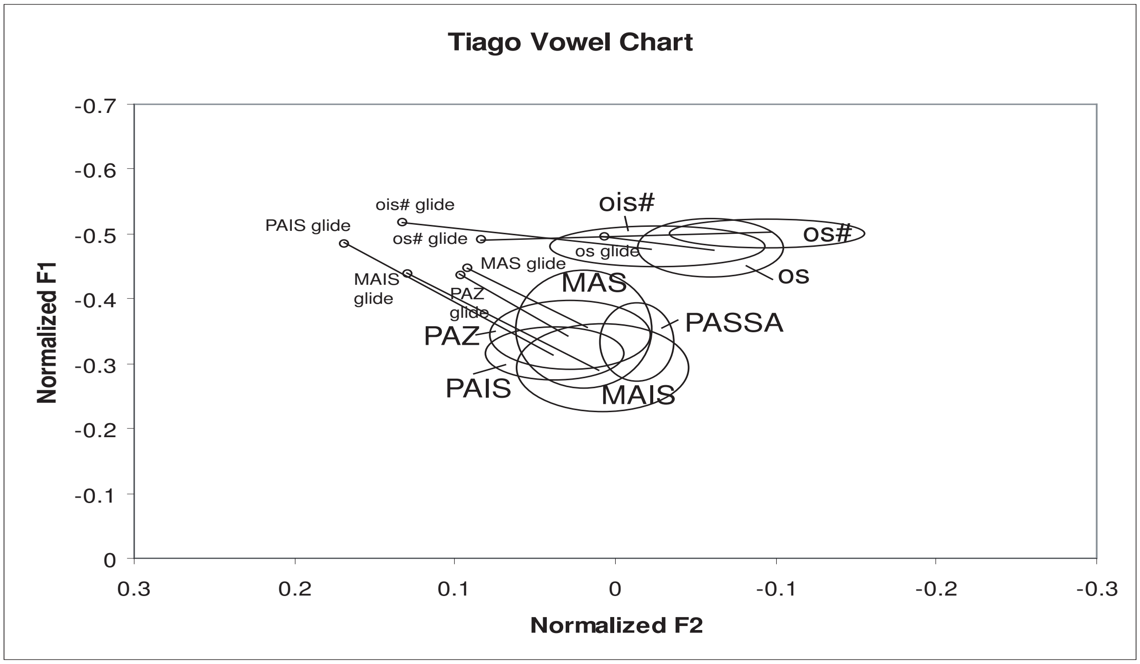

Figure A.35 : Vowel chart for Tiago (M, 55, Lower).

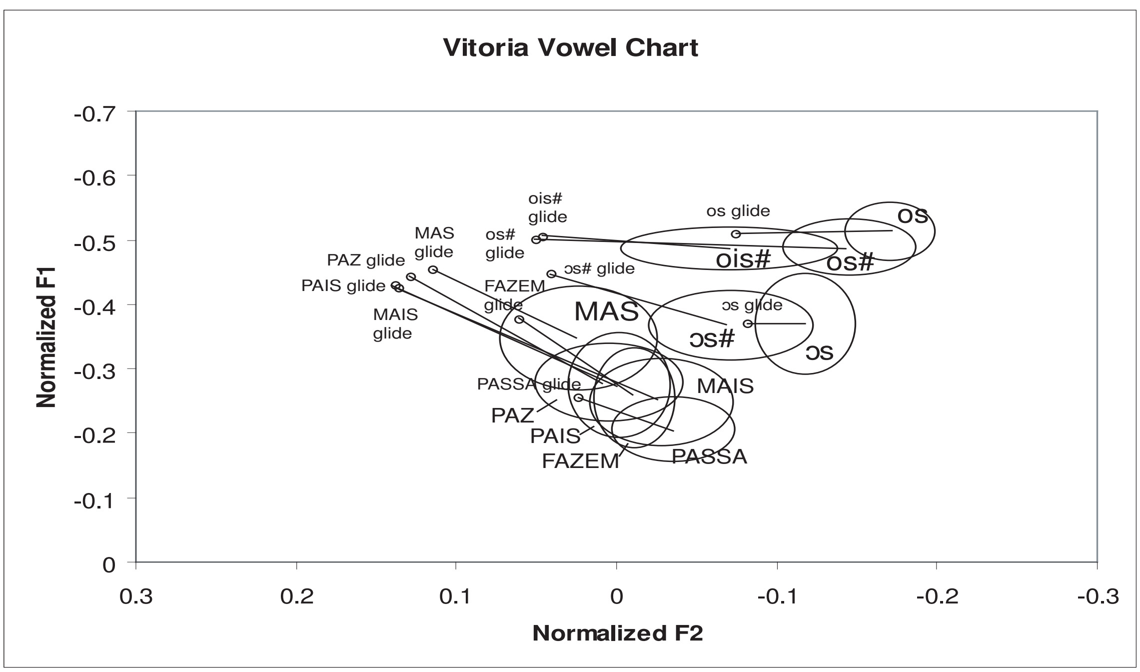

Figure A.36 : Vowel chart for Vitória (F, 35, Upper).