TEMPORAL ORGANIZATION OF BRAZILIAN PORTUGUESE VOWELS IN CONTINUOUS SPEECH: AN ACOUSTICAL STUDY

by

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To the memory of my father, Geraldo,

to my mother, Ilka,

to my wife, Hélène,

and to my sons Fábio and Bruno.

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Temporal organization of Brazilian Portuguese vowels in continuous speech: an acoustical study

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Previous experimental linguistic studies on the time domain have either listed and discussed linguistic phenomena related to duration or, in a further step, have used these results to propose models which predict sound-segment duration. This dissertation attempts to provide two contributions: (1) an experimental analysis of the durational patterns for Brazilian Portuguese in comparison with English; and (2) an adaptation of Klatt's (1976) model, based on English, to predict sound-segment duration of Brazilian Portuguese in continuous speech. Analysis of continuous speech is, in general, a recent trend, and in Portuguese linguistics it is a relatively unexplored area. The main intention of this investigation is to obtain data on the three extreme oral vowels /i, a, u/.

Variations in segmental durations seem to mark language components during the speech act in both American English and Brazilian Portuguese. The present study concludes that for the speaker analyzed, sound-segment duration in the acoustic domain distinguishes (1) a stressed from an unstressed or

reduced vowel, (2) four word positions: stressed, two types of pretonic, and postonic, (3) voiced from voiceless postvocalic consonant, (4) presence of a syntactic boundary not physically present (prepausal lengthening of non-word-final vowels), and (5) presence or absence of emphasis. Conclusion (1) evidences further that the speaker in this analysis has a predominantly stress-timed rhythm shown in a stressed : unstressed ratio greater than 2 : 1.

Klatt (1976) concluded that in American English duration is a primary perceptual cue to distinguish (1) inherently long versus short vowels, (2) voiced versus voiceless fricatives, (3) phrase final versus non-final syllables, (4) voiced versus voiceless postvocalic consonants, as indicated by changes to the duration of the preceding vowel in phrase final positions, (5) stressed versus unstressed or reduced vowels, and (6) the presence or absence of emphasis. Conclusions (1), (2) and (3) in Klatt's work are not observed at the acoustic level in the speech of the speaker in this study.

From the standpoint of modeling Brazilian Portuguese vowel duration it is suggested that linguistic components (syntax, semantics, word level, and phonology (phonetics)) influence duration significantly as a single factor at times, but in general, two or more of these components act together operating cyclically. Based on the acoustic and statistical analysis results, rules of vowel duration change (lengthening and shortening) are proposed for the specific case of this speaker of Brazilian Portuguese. These rules apply cyclically from inner domains (phonemes, syllables) to outer domains (utterances).

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Chapter 1. Introduction

1.0. Introduction

Most analyses in phonetics use duration, intensity and frequency as basic parameters. This study concentrates on the analysis of duration. Although it is not linguistically significant in Brazilian Portuguese (hereinafter BP), there are several reasons for concentrating so much effort in analyzing duration.

For example, results of the present study suggest that the speaker analyzed has a predominantly stress-timed rhythm. This finding is in agreement with a work by Abaurre-Gnerre (1981) and with two works done by Major (1981, 1985). The details of pattern variations in the rhythm of the speaker analyzed here are better interpreted by Abaurre-Gnerre (1981), who suggests a stylistic criterion in analyzing rhythm. Major's (1981, 1985) stylistic criterion does not apply to the present analysis as readily as does that of Abaurre-Gnerre (1981). Further, it could be inferred from the present analysis that there are significant phonetic changes occurring in BP at this moment.

Besides the usefulness of duration in analyzing rhythm, there are practical applications. Charles Read (personal communication) is attempting to use Klatt's (1976) conclusions to improve listening comprehension of children, by giving extra duration to words at syntactic boundaries of recorded readings. Duration is a parameter which likely contains information about all linguistic components, as the results of this investigation suggest.

1.1. Objectives

From information obtained in the context of a narrative read by a single speaker of Brazilian Portuguese, a purely acoustic analysis of the duration of the oral vowels /i, a, u/ is conducted. Arguments based on perceptual and articulatory concepts are not attempted although these areas of phonetics also need further analysis. The significance of the acoustic data obtained is assessed by statistical analysis.

Segmental duration is reflected as two linguistic phenomena: *reduction* and *expansion*. The goal of the present study is to find the factors (language components, language levels) that make vowel segments shorter or longer, relative to a given *inherent duration*. The term "inherent" is borrowed from Klatt (1975, 1976) and it is used interchangeably with the term *unmarked* (see discussion on pp. 32ff).

The *unmarked duration* of a given sound-segment μ is defined here as the *median* duration of all the occurrences of that sound-segment μ in a text of over one-thousand words.

The goals of the present work are:

[1] To uncover the factors or language components that affect sound-segment durations by both shortening and lengthening vowel duration.

[2] To determine how these factors interact. Do they interact simultaneously or in series? If in series, is there an ordering process?

[3] To determine vowel-duration change rules for the specific case of this BP speaker fitting D. H. Klatt's model (1976) to predict duration of the three vowels studied.

1.2. Broad phonetic inventory from the corpus in terms of acoustic phonetics

The complete, broad inventory of the linguistic sounds of this speaker, classified in term of the Transfer Function Theory for the vocal tract filter (Fant, 1970), is shown in Table 1:

Table 1: The complete broad transcription of the speaker PM presented according to Fant's (1970, 15-26) Transfer Function Theory. Both articulatory and acoustic terminology are combined in the description.

S	*T*	$P = S \times T$*	
periodic airflow	(fixed) oral	oral vowels	ɩ, e, ɛ, a, ɔ, o, ω
	(fixed) oral+nasal	nasal vowels	ɩ̃, ẽ, ã, ɔ̃, ω̃
	(changing) oral	diphthongs**	ɩ^w, e^i, e^w, ɛ^i, ɛ^w
			a^i, a^w
			ɔ^i, ɔ^w, o^i, o^w, w^i
	(changing) oral+nasal	nasal diphthongs	ã^i, ã^w
			ɔ̃^{i}
aperiodic airflow, continuous	(fixed) oral	voiceless fricatives	f, s, š, x
aperiodic airflow, interrupted	(changing) oral	voiceless stops	p, ɩ, k
periodic+aperiodic, continuous	(fixed) oral	voiced fricatives	v, z, ž
	(changing) oral	semi-vowels	*i*, *w*
		laterals (approximants)	l, r, λ, [ʁ]***
periodic+aperiodic, interrupted	(changing) oral	voiced stops	b, d, g
	(changing) oral+nasal	voiced nasals, stops	m, n, η

(*) *P* = *product*, *S* = *source*, and *T* = *transfer function.* *(**) Phonologically there are no raising diphthongs in BP. See Câmara (1977). (***) As discussed in Chapter 5 the velar fricative /x/ is realized as an approximant.*

1.3. Notational devices used in the analysis

The notational devices used in this study generally identical to those used in similar studies (Head, 1964; Ladefoged, 1975). A few new symbols were created when needed, to reflect the acoustic characteristics of certain sounds. The vowels studied here are defined in this section in terms of articulatory phonetics. During the discussions their phonetic symbols [ι, a, ω] are used instead of repeating their phonetic description each time they appear.

Notational devices:

symbol	ι	high, front, oral vowel
symbol	a	low, slightly front, oral vowel
symbol	ω	high, back, oral vowel
subscript	∘	devoiced
superscript	~	nasality
superscript	h	palatalization, aspiration or frication
subscript	•	syllabic status
superscript	⁀	linking
symbol	.	syllabic boundary
underscore	_	word boundary
colon	:	extra long duration
superscript	"	melodic stress
superscript	'	word stress
slash	/	weak energy when superimposed on a given

		sound: [ɸ̸, ʃ̸, ʒ̸, χ̸]
superscript	ˀ	burst or glottal stop
superscript	↘	usually superimposed above fricatives ([s̀↘]), it means a formant transition within a consonant.
superscript	↑↑	sharp melodic rising
superscript	↓↓	sharp melodic falling
superscript	↑	moderate melodic rising
superscritp	↓	moderate melodic falling
symbol	→	flat melodic evolution
brackets	[ ]	phonetic transcription enclosed
slant lines	//	phonological transcription enclosed
symbol	F1	first formant
symbol	F2	second formant
symbol	T1	first formant transition
symbol	T2	second formant transition

1.4. Summary of the chapters

Most chapters are organized with phonological factors first, then proceeding through word factors, sentence factors, semantic factors and ending with models. Chapter 2 provides background on the general topic of BP. It gives a brief introduction to BP with a more detailed discussion of the works that used duration to analyze experimentally some aspects of BP, a survey of some of the studies on duration using other languages and definitions of concepts applied in the present analysis. The survey of works on duration is done mainly to reinforce the notion that such analysis has produced major works in experimental phonetics. Chapter 3 contains detailed information on the methodology of the experimental analysis as well as rules for manual segmentation of speech-sound segments. The use of speech-instruments and statistical techniques in the present study is discussed also. Chapter 4 presents results obtained using the methods described in Chapter 3. Chapter 5 discusses and interprets these results. This discussion prepares a path for future attempts to explain the phenomena observed. Chapter 5 ends with rules for prediction of vowel lengthening and shortening in the continuous speech of the speaker analyzed in this investigation. Chapter 6 concludes the investigation and offers suggestions for further studies.

Chapter 2. Background

2.0. Introduction

Detailed accounts on the general trends as well as the general principles of BP have been presented by several scholars, notably Head (1964), Câmara (1968), Naro (1982), and Major (1985). This chapter provides a brief account of works on BP as a background to the present study and a non-exhaustive survey of works on duration. Then, three concepts used in the present analysis are defined: function word, content word and unmarked/inherent word. As part of the definition a list of members of each set of function and content words is provided. The chapter ends with a question on methodology which also has theoretical consequences: the true duration of a speech-sound.

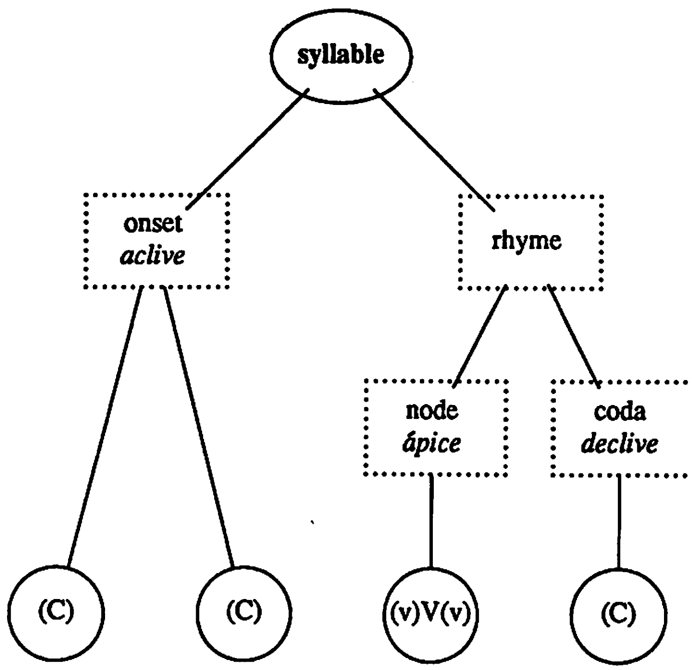
2.1. General points: Brazilian Portuguese

The development of Brazilian Linguistics shows a passage from a first stage which was a simple collecting of phonetic facts, up to the 1930's, into a second stage, the interpretation of these facts. This second stage seems to have started with Hall (1943). Current major areas of disagreement include:

1. Interpretation of the nasal vowels.
2. Interpretation of the semi-vowels which affects the interpretation of the diphthongs.

The question of how to analyze the consonants and the oral vowels has now been resolved: there are 19 consonants, semi-vowels not included, and seven oral vowels (Head, 1964; Câmara, 1977). The syllabic structure of BP is presented in Figure 1.

Figure 1. The syllabic structure of BP according to Câmara (1969, 26ff; 1979, 61-62), adapted in terms of tree diagram. In tonic and pretonic positions there are 0-2 elements in the onset and 1-4 elements in the rhyme (Major, 1985).



Presently, in addition to the interpretation of linguistic phenomena, Brazilian scholars are further attempting to *explain* and *apply* models of analysis intending such an explanation (Bortoni-Ricardo, 1985).

In Brazilian linguistics, studies on duration *per se* have not resulted in any major work nor brought any major discussion. To my knowledgment the present research is the first of its kind. The works that deal phonologically only or experimentally and phonologically with duration of speech-sounds in BP are the ones by Abaurre-Gnerre (1981) and by Major (1981, 1985).

Duration in Major's work is only a part of a broader study on BP prosody. Major (1981, 1985) brought in some propositions, inspired by current trends in American Linguistics (Liberman and Prince, 1977; Prince, 1983; Selkirk, 1980; Hayes, 1984, and so forth) which could foment disputes and inspire important developments in Brazilian Linguistics. His research is limited to the isolated-word domain, a rather serious limitation for some. One of Major's conclusions is that rhythm in BP is stress-timed, and that "this rhythm patterning is present both synchronically and diachronically, and it operates as style changes from formal to casual" (1985, 260).

> However, because these pretonic and postonic differences are lessened as style changes from CIT[ation] to NOR[mal] to CAS[ual] (allowing pretonic syllables to be reduced, and perhaps with a concomitant decrease in stress), the language becomes increasingly stress-timed as style becomes more casual. These observations suggest that sentence-level rhythmic tendencies (i.e. stress-timing) can disrupt or alter word-level rhythmic patterns. (Major, 1985, 280)

It is understandable that the language becomes increasingly stress-timed as style becomes more casual. The difficulty, however, to accept the levelling of pretonic and postonic in a stress-timed rhythm, as Major appears to suggest. In the present study postonic positions are greatly reduced in relation to both pretonic and stressed positions. Levelling of syllable length should be expected in a syllable-timed language.

In an earlier work, Major (1981, 350) concluded: "[probably Brazilian]

Portuguese is in the process of changing from syllable-timed to a stress-timed language." However, Major's conclusion was based on the use of carrier sentences such as "Say ____ again." Changes in style may in fact create changes in rhythm as Major (1984) claims. A limitation in Major's work is to distinguish between styles by means of carrier sentences. Study of rhythm by means of carrier sentences requires excessive abstraction to make up for information readily available in larger utterances. Style changes in Major's experiments were induced through directions to the readers such as "read the sentence in normal, natural style" (1981, 344), for a "normal" style; to obtain a "casual style" Major's speakers were instructed to "repeat the sentence rapidly" (1981, 347).

Major's (1981) discussion of the status of pretonic versus postonic reductions in syllables suggests that the reductions are linked to the style used. In the present study the corpus analyzed shows different rhythmic patterns that can be accounted for by the speaker's changes of style. The next paragraph discusses this point. present study do not consider style differences. The phonological processes observed in pretonic and postonic positions in this study confirm Câmara's (1977, 47ff) interpretation which relates reduction to the type of syllable in pretonic position (see pp. 99ff).

In terms of qualitative observations made in the present study, the speaker of BP examined in this study sometimes shows isochrony of stresses in his readings, but sometimes he skips several expected "beats" breaking this isochrony. If this qualitative observation is maintained under empirical analysis, then it will be a case in which the speaker *manipulates* both stress-timed and syllable-timed rhythm. Evidence for this stress-timed rhythm comes from passages where vowels are either greatly expanded, reduced or fully deleted. On the other hand, empirical evidence for syllable-timed rhythm, although less frequent in this speaker, is seen in consonants which, unlike the vowels, reduce or expand, as if a certain syllable duration were to be maintained. This was observed on many occasions. For example, if the second "a" in "'pássaro" ['pa.sa.rω] is deleted, or reduced to almost full deletion (schwa-like vowel), either the preceding [s] keeps that syllable like ['pa.s:.rω] or a centralized [a] is present ['pa.s^{a}.rω]. But neither ['pas.rω] nor ['pa.srω] appears. This observation confirms an observation made by Grammont (1933) who suggested that the same notion which allows for liquids to be syllabic nuclei can also be extended to consider fricatives as syllabic nuclei as well.

Further evidence for syllable-timed patterns in the present study is found in the form of the speaker's tendency to delete final consonants making CVC sequence to become CV sequences. This observation was also made by Abaurre-Gnerre (1981). Abaurre-Gnerre observed that the deletion of the final consonant created CV sequences characteristic of syllable-timed languages.

The play between stress- and syllable-timed rhythm observed in the speaker in this analysis, was also observed by Abaurre-Gnerre (1981), who suggested a scale including variations in language rhythm as one shifts from a formal style (slow rate of speech) to a colloquial style (fast rate of speech). Paralleling this style scale, the rhythm varies from syllable-timed (formal) to stress-timed (colloquial). She placed BP in the center of the scale. Spanish and English are examples of languages on the extremes of the scale, i.e. syllable-timed and stress-timed respectively (Abaurre-Gnerre, 1981).

2.2. General points: Studies on duration

In the work of Klatt (1976) and many others scholars (Peterson and Lehiste, 1960; Lindblom and al, 1981), temporal patterns contain important information regarding the hierarchy of linguistic components as well as information of practical use for speech synthesis-by-rule, automatic verification and recognition, speech pathology, diachronic and synchronic phonology, etc. Functional integration and perception of speech cannot be dissociated from the time axis.

Many studies have dealt with duration either as an analyzed parameter, descriptively, or with the goal of predicting duration in models (Denes, 1955; Belasco, 1958; Kim and MacNeilage, 1973; Klatt, 1974; Lehiste, 1970; Lindblom and Rapp, 1973; Klatt, 1976; Lindblom and al, 1981; Lyberg, 1981; etc.). Some of these works are briefly reviewed here. The works of Klatt are discussed in more detail in Chapter 5. Several factors influencing duration in speech were identified by different authors studying different languages. Some of these factors were the rhythmic foot, *viz.* timing (Pike, 1945; Kozhevnikov and Chistovich, 1965 Noteboom, 1972), word size (Barnwell, 1971; Umeda and al, 1973; Klatt, 1973b; Klatt, 1974), intrinsic duration in vowels (Peterson and Lehiste, 1960; Klatt, 1975), semantics (Kloker, 1975; Schreiber and Read, 1982), and syntax (Gaitenby, 1965; Klatt, 1971, 1975). Most of these studies furnish elements for models that seek to predict sound-segment duration.

As Fant (1970, 224) puts it, "the simple and fundamental cue of duration deserves greater attention than is conventionally paid to it."

The survey that follows considers some of the many works on duration in chronological order. The explanation of their results requires incursions into the areas of articulatory phonetics and perception which are areas avoided in the present study. However, a modest interpretation of what makes a sound-segment longer or shorter is suggested.

2.2.1. *Phonological and phonetic factors*

Martinet (1949) realized that there existed a universal tendency in languages for tense consonants to shorten vowels following them and for lax consonants to lengthen vowels following them. Also, Jakobson and al (1952) observed that tense consonants (f,s,š,p,t,k) are longer than lax consonants (v,z,ž,b,d,g). House and Fairbanks (1953), Denes (1955) and Belasco (1958) find that tense consonants are preceded by vowels shorter than their corresponding sonorant consonants. In the study done by Fry (1955) showed that duration and intensity ratios are both cues for judgments of stress in material he studied, duration ratio is a more effective cue than intensity ratio. In other words, duration contrast functions as a cue to distinguish between similar phonetic segments. Miller and Nicely (1955) proposed the acoustico-physiological feature "duration" to distinguish [s,š,z,ž] from 12 other consonants in their study.

According to them, these four consonants are long, intense, and contain high-frequency noise, but in their opinion it is their extra duration which is most effective in setting them apart. Peterson and Lehiste (1960) noted that duration is affected by the nature of the consonant after a syllable nucleus, namely, a syllable nucleus becomes longer when followed by a voiced consonant and shorter when followed by a voiceless consonant; however, the longest syllable nucleus appears when what the nucleus is followed by a voiced fricative. Lisker and Abramson (1964) found the time between the onset of a given consonant and the onset of the vocal cord vibration was important in the distinction of consonant pairs in English. Lehiste (1970) found that vowels are longer in open syllables than in closed syllables, and that fricatives make vowel durations longer than do stops. Peterson and Lehiste (1960) results were more or less confirmed in Bush (1972) where she found that [f,v,θ,δ] become longer when followed by [i, u] and shorter when followed by [a].

Kim and MacNeilage (1973) concluded that in English [f] is inherently shorter than [s,š]. This inherent characteristic of [f] was also confirmed in French by Chafcouloff and al (1976), who also, observed that all constrictives, especially in bisyllabic words, become longer if followed by French [i,y,u], but [š] becomes shorter in contact with the rounded, mid, front [oe]. The results from Ferrero and al (1979) for Italian showed that shortening of frication duration in Italian unvoiced fricatives [s,š] does not bias perception toward the corresponding [z,ž] as English does (Cole and Cooper, 1975), but instead toward the unvoiced affricates [ts, tš].

At the phonological level, the results described above can be seen as a confirmation of preceding results. A general synthesis of these results shows that duration at the phonological and phonetic level is affected by articulatory effort. When a minimal effort is required, there is a reduction of the targeted sound-segment, whereas under maximum articulatory effort there is a lengthening of the targeted segment. The sounds adjacent to the targeted sound are affected differently in each language. In American English and Brazilian Portuguese the results indicate that adjacent sounds take the inverse magnitude of the targeted sound: lengthening of the targeted sound produces a shortening of adjacent ones, and vice-versa. Finally, articulatory effort will be greater during vocal cords vibration, stressing of a sound-segment, or in articulatory displacements (distance) when there is a passage from one point to another. As Lehiste (1970) remarks, the longer the displacement the longer the sound-segment.

2.2.1.1. *Rhythmic factors*

The study of rhythm using analysis of duration has been used by many scholars in their attempts to explain speech phenomena. Kozhevnikov and Chistovich (1965) proposed a speech production model using the average length of seven syllables as a rhythmic foot. In other words, the rhythmic program for a word is independent of the differences in the length of the word. Noteboom (1972) repeated Kozhevnikov and Chistovich (1965) experiments in his analysis of Dutch. Noteboom confirmed the idea that subjects are much more aware of duration if a monotonous pitch is used than if normal pitches are used. Intonation affects duration. Rhythmic program for a word, Noteboom explained, is independent of the difference in *longness* and *shortness* of words. Martin (1972) also studied the rhythmic structure of speech and his conclusions were based on the analysis of the temporal organization of interstressed strings of syllables. In more abstract areas of analysis, such as phonological theory, one finds works such as Pike (1945, 34), where it is argued:

> The tendency toward uniform spacing of stresses in material which has uneven number of syllables within its rhythm groups can be achieved only by destroying any possibility of even time spacing of syllables. Since the rhythm units have different number of syllables, but a similar time value, the syllables of the longer ones are crushed together, and pronounced very rapidly, in order to get them pronounced at all, within that time limitation.

Then, Pike exemplifies by contrasting sentences like:

"If 'Tom will 'I will."

"If 'Tom'll do it 'I will."

Rhythm, then, may be independent of word duration as Kozhevnikov and Chistovich (1965), and Noteboom (1972) propose, or dependent according to Pike's (1945) suggestion.

2.2.2. *Word factors*

Lehiste (1959) showed that duration marks word boundaries. Lehiste (1970) suggested that the [s] becomes lengthened at the beginning of a word and becomes shorter in final position. Raphael (1972), in an experiment using synthesized word final fricatives, found that pairs of English fricatives contrast in perception of voicing mainly along the acoustic parameter "frication duration" rather than along the parameter "presence-absence of vocal cord vibration." Umeda and al (1973) and Klatt (1974) find two other factors which lengthen consonant at the word domain: the number of syllables in the word and the position of the consonants in the word. Simões (1980) confirmed these results in an analysis of the fricatives [s,z] of BP and also found that the interaction of these factors was statistically significant. Major (1981, 1985) (see pp. 22ff), concluded that any phonological process in BP has to take place first at postonic position, then pretonic and then in stressed position.

These studies indicate that, at the word level, duration is linked to word position, length of words, word boundary and the interaction of the factors.

2.2.3. *Syntactic factors*

Gaitenby (1965, in Klatt (1976)) found that duration is a parameter that delimits syntactic units. This information is crucially important since it lies at the basis of my use of Klatt's model. Schreiber and Read (1982) used these results as described below.

Harris and Umeda (1974) find the last vowel before a pause to be longer than vowels in positions other than prepausal. In Cooper (1976), we see that in English there are different degrees of lengthening before different syntactic boundaries within a sentence. B. Lindblom (1978) confirmed the importance of lengthening in syntactic preboundaries. The results from Lehiste (1979) also present these signalings of syntactic boundaries, but her results do not support a difference between *sentence* and *paragraph* based on preboundary lengthening.

2.2.4. *Semantic factors*

There are several works which link duration to emphasis, contrastive stress, topicalization (focus), and word novelty (Klatt, 1976, 1210). These results have been used in the design of models that attempt to include semantics (see, for example, Umeda (1975)). A more recent application of results linking duration to semantics has been attempted by Schreiber and Read (1984). These authors gave extra duration to words at syntactic boundaries to improve the listening comprehension of children. However, they have not observed improvements in the listening comprehension of adults under the same conditions. This may reflect some support for Kloker's (1975) observation that deceleration at the end of syntactic units is a strategy used by some speakers to emphasize syntactic units and their contents.

2.2.5. *Models based on duration*

For English Klatt (1976) suggests that recurrent rules shorten or lengthen inherent durations from smaller units (phoneme), i.e. locally, up to higher units (sentences), operating cyclically, and for Swedish (Lindblom and Rapp, 1973, 47), suggest the inverse applies, i.e. from higher units into smaller units, down to the word domain, only. Recently, Lindblom and al (1981) extended Klatt's (1976) formula and developed several hypotheses about the psychology of speech timing. In their extension of Klatt's formula, Lindblom and al (1981) applied duration change rules cyclically from smaller to higher units.

Both models approach vowels and consonants differently. In establishing inherent durations of vowels, the vowels' inherent durations are derived from phrase-final monosyllables ending in a voiced stop, i.e. /bag/ or /big/. In the case of the vowels the model is based on an inherent *longest* duration. In the case of the consonants, the inherent duration is derived from word initial position in a prestressed monosyllable. The consonant, then, is neither derived from a longest nor from a shortest inherent duration.

2.3. The notion of function word and content word

It is necessary to define as precisely as possible these word classes in order to make any valid study of a parameter such as duration. Depending on its function, a word can be expected to be inherently longer or shorter. These notions of function and content words are closely tied to decisions concerning stressed and nonstressed vowels in the sentence domain, i. e. timing (Pike, 1945; Martin, 1972; Allen, 1972, 1973, 1975; Klatt, 1976; and so forth). It may be more helpful to refer to function words *relational words*.

The task of classing certain groups of words such an prepositions, clitics, articles as relational words is not problematic. It also poses no problems to identify nouns, verbs, adjectives and adverbs as content words since they carry meanings of their own. To which group should we assign the copulas "ser" and "estar" (both translate as "to be"), numerals, interjections, exclamatory and question words, prepositioned pronouns, demonstratives and possessives? The following section is an attempt to answer this question.

2.3.1. Inherently stressed and unstressed words

I propose here a classification which will be helpful in dealing with other areas such as rhythm. The classification proposed starts from *inherently (unmarked) stressed words* which are more important because of their meaning than their function as structure signaling elements. At first, nouns, verbs, etc. and the less problematic classes are classed as inherently stressed; secondly, articles, prepositions, etc. by the same token are classed as *inherently (unmarked) unstressed.* Linguistic evidence (experimental phonetics and general linguistics) will help in deciding about the other classes.

A more sophisticated approach combining general linguistics knowledge with experimental research, although difficult to handle, should provide more elegant insight in to what is happening in the speech chain. Following this line of thought, two groups of words are developed into *inherently stressed words* and *inherently unstressed words.* This notion can be found discussed in Pike (1945), Gleason (1955), Martin (1972), Stockwell (1977) and so on. However, in the case of BP there remains a need to specify the members of each group in an approach similar to Pike's (1945). Finally, the term "inherent" is misleading and this concept is better understood among linguists if the notion of *markedness*[1] is introduced, instead. In the case of Brazilian Portuguese it seems that an initial attempt at specificaton might include:

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[1] Stockwell (1977) and other basic linguistics textbooks discuss this notion. I owe to Professors Dale A. Koike and F. Hensey the suggestion for using the notion of "markedness" instead.

Unmarked stressed words

main verbs, the verb "estar" when not an auxiliary, the verb "ser" in tenses other than the present tense, nouns, titles ("o senhor," "dona," etc.) adjectives, intensifiers, numerals, exclamation and question words, possessives, demonstratives, interjections, prepositional clitics ("como *eu*", "sem *você*, etc.).

Unmarked unstressed words

the verb "ser" in the present tense, auxiliary verbs, the negative "não", prepositions, articles, clitics (*atonic pronouns* such as subjects, objects and reflexives), conjunctions and expletives.

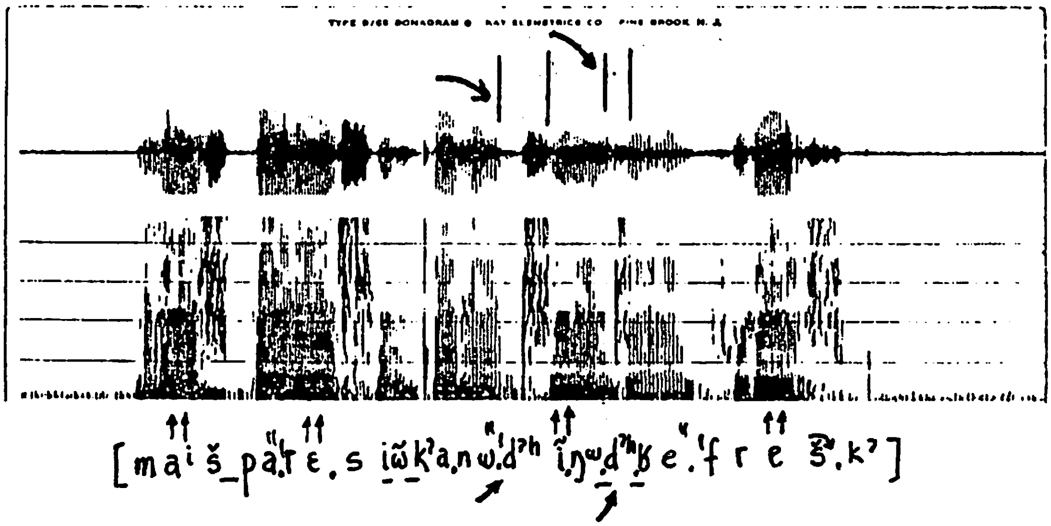
This specification is proposed to cover the corpus analyzed here. Such a specification depends on correctly deciding which elements are inherently relational and which are not. There are words which are relational, but with some meaning at the surface domain. For example, the word "quando" ("when") is primarily relational but it does have the semantic feature [+temporal]. Words like "quando" seem to have always long duration because its individual sound-segments are physically (phonetically) longer, despite their function. This is due at least to two factors: the lengthening characteristics of the nasal consonant present in the word "quando", and the size of the word "quando." This is a situation where a descriptive analysis can help. It is inefficient to assign a case such as "quando" to both relational and content groups. This aspect of linguistics can have a full support from experimental phonetics if the whole corpus has been measured. This will eventually be done in a future work. In the present study, "quando" and other relational polysyllabic words are considered unstressed bearing in mind the notion of *unmarkedness*.

2.4. What is the true duration of a given sound?

There are no standard ways of measuring duration of segments. Peterson and Lehiste (1960), and Klatt (1973, 1975, 1976), include the burst of a stop consonant and any aspiration in a vowel when that vowel follows a stop consonant. Studies on coarticulation (Menzerath and Lacerda 1933; Lindblom, 1973; Kozhevnikov and Chistovich, 1965; Ohman, 1966, 1967; MacNeilage and DeClerk, 1969; Parker and Diehl, 1984) show that consonants and vowels might be co-produced rather than assimilated. If co-production is the case, it could be argued that the true duration of the vowels is minimized if the method used segments vowels by measuring only the time extent of their formant structures: either from the beginning of the vowel onset to the end of the vowel offset, or the vowel steady state. On the other hand, the "anticipatory coarticulation" that some of these studies also observe (Daniloff and Moll, 1968; MacNeilage and DeClerk, 1969; MacNeilage, 1970) shows that if one considers the whole syllable as the true duration of the vowels, the duration that permeates throughout speech sounds outside syllable boundaries should also be considered. Thus, it could be argued that measurements of the whole syllable as the true vowel duration, overestimate the true vowel duration. It becomes then, a matter of choosing and maintaining an acceptable methodology for segmentation.

For the purpose of uniformity, I decided to use part of Klatt's approach. Klatt described a tested method for speech synthesis-by-rules and possibly for automatic recognition of speech (personal communication). Klatt's approach to segmentation of speech-sound, which is an extension of the work of Peterson and Lehiste (1960), was surprisingly applicable in the case of this Brazilian speaker. His procedure made the almost unmanageable task of segmenting connected speech manageable. This is especially true in situations involving a stop followed by [ɩ]. Very often, from the acoustic image there would be no formant structure for [ɩ], although when listening informally to the tape the [ɩ] is present. Again, the problem such an approach presents in BP is that the release of the resultant affricate is so important that the duration of [ɩ] is possibly being overestimated. However, it should be kept in mind that this investigation also has a practical goal: speech synthesis, verification of the speaker, automatic recognition of the speaker, in addition to its descriptive linguistics side. A purely descriptive linguistic analysis would probably consider a word such as "de" (Eng. "of" "from") as a string of this sort [ǰɩ], whereas here, the segmentation done considers a string of this sort: [d^{h}ɩ]. Figure 2 below illustrates this.

Figure 2: The sentence "Mais parece um canudinho de refresco" (She looks more like a little beverage straw) has two examples of /di/ realized as [ʝɩ] (or [d^hɩ].), as indicated by the arrows.



2.5. Summary of chapter 2

The survey and discussion presented in this chapter concentrates only on points relevant to the present analysis. For general information about BP the works of Mattoso Câmara (1977, 1979) are used. Only two works on duration in BP are discussed because only these works are published in accessible journals: Abaurre-Gnerre (1981), in a phonological analysis, and Major (1981, 1985), in both experimental and phonological analysis. These investigations use duration only as it applies to rhythm of BP, their main interest. The present investigation concentrates on duration and from analysis draws conclusions about other aspects of BP, e.g. rhythm.

Abaurre-Gnerre's (1981) placed BP midway in a scale from stress- to syllable-timed rhythm, while Major (1981, 1985) suggested a stress-timed rhythm. Major also suggested that BP is presently undergoing linguistic change from syllable-timed to stress-timed. The present work supports Abaurre-Gnerre's conclusion because the speaker here does show evidence of a play between both stress- and syllable-timed rhythm in his speech.

A general synthesis of studies on duration in other languages shows that duration at the phonological and phonetic level is affected by articulatory effort. Two conclusions on rhythm can be contrasted: rhythm may be unrelated to word duration as Kozhevnikov and Chistovich (1965) and Noteboom (1972) proposed, or related as Pike (1945) suggested. Syntactically, duration seems to signal syntactic boundaries up to the sentence level. Lehiste (1979) did not find signaling of paragraphs by durational changes. The semantic factors that affect duration are emphasis, contrastive stress, topicalization and word novelty. Durational changes at the syntactic and semantic levels may be interpreted by the speaker's planning of the next units.

Two models were briefly introduced to predict and explain durational changes. They were models designed for American English and Swedish. The American English model is the one used in this investigation. Lindblom and al's (1981), model should perhaps be considered in future work on duration. Both models use the longest duration as inherent duration for vowels. The present model differs, because of the phonotactics of BP, and uses the median duration of each vowel.

Finally there is an attempt to clarify three concepts basic to the present study: function and content words, inherent stressed and unstressed words, and the true duration of sound-segments. The categories of inherently (unmarked) stressed and unstressed words cannot be established by simply stating that they are content and function words respectively. A list of the members of each category must be provided as was done here. Finally, the true duration of a sound-segments cannot be decided theoretically. As previous works have shown it is a matter of methodology, and thus, still an arbitrary decision.

Chapter 3. Experimental protocol

3.0. Introduction

The experimental protocol is organized according to three main procedures: the production of the corpus (recordings), the production of spectrograms for sound-segment segmentation, and data analysis.

In the first section, most of the procedures have been used in speech analyses in different laboratories, but this seems to be the first time the specific rules of the present work have been written. However, the superimposition of spectrograms as presented here is a result of this investigation.

In the second section the data analysis is done through extensive observation of the characteristics of a single speaker's speech-sounds. Observation of the spectro-temporal evolution of the speech analyzed is necessary before deciding how to conduct the analysis. For example, simple statistical techniques have proven as satisfactory methods as highly complex multi-variant analysis.

The next section describes the factors studied, with some examples of how the linguistic analysis has been done. The chapter concludes by introducing statistical techniques, the methods for establishing stress groups, and a first approach to rhythm and intonation patterns.

3.1. The production of the corpus (recordings)

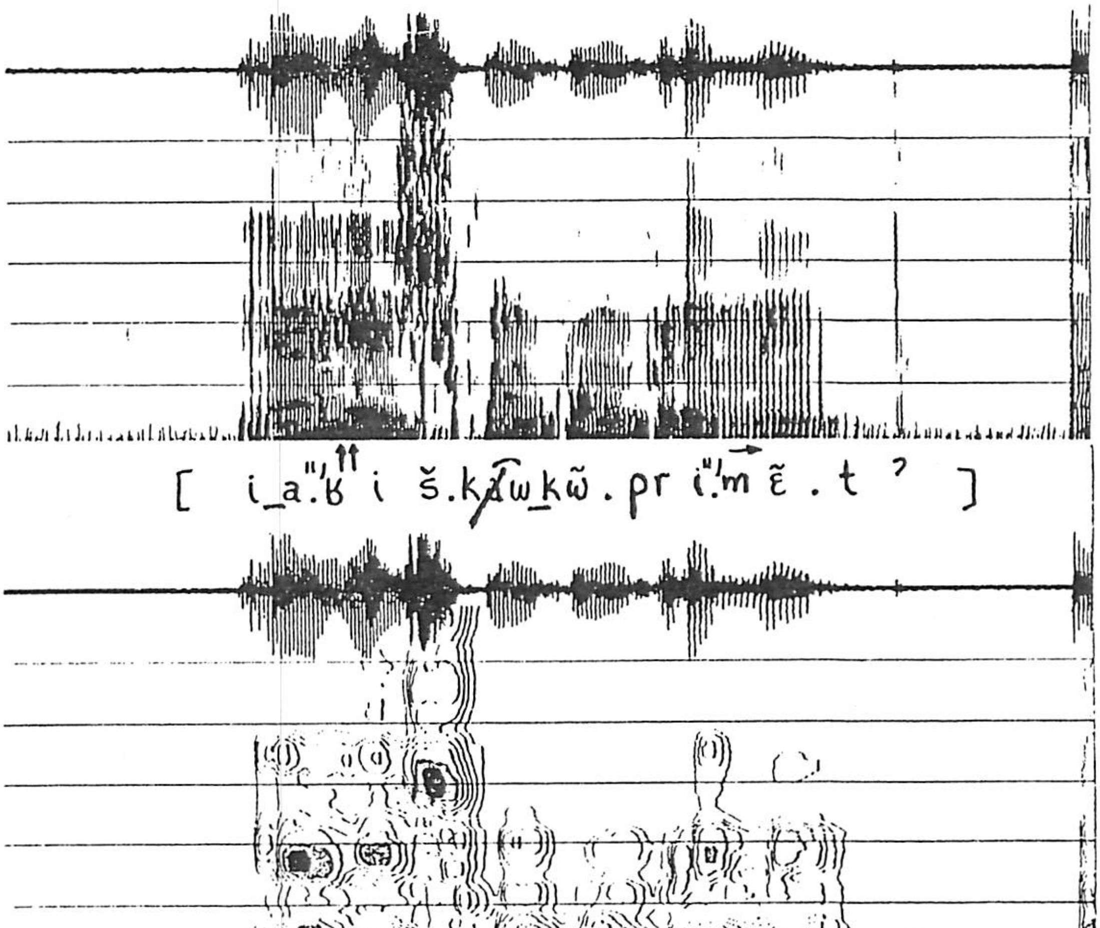
A single speaker of Brazilian Portuguese, PM, 32 years old, from Rio de Janeiro, was recorded. PM read a 1286-word text for children (see Appendix _ for the complete text) in two recording sessions. The recording sessions took place one week apart. PM was asked to read the same text three times in each session, totalling six readings of the same story. The third reading of the second session, i.e. the sixth recording, is the one used in the analysis.

The recordings were made at the UT language laboratory, in Batts Hall with the help of a lab technician. An acoustically isolated recording booth was used and the recording was done using a AKG dynamic, unidirectional cardiod microphone situated at 40 cm from the subject's mouth. Before each recording the system was calibrated. The tape used is an AMPEX tape, 1/4", 1.5 mil, mylar.

3.2. The production of spectrograms for sound-segment segmentation

Some 700 spectrograms were produced to observe and measure the 1286-word text and its sound-segments in this study. The spectrograms were obtained through a stereo tape deck TEAC A-2300SX coupled to a Digital Kay Sonagraph 7800. The analysis of connected speech requires a special use of the Sona-Graph. To use only the usual 3D broad band spectrograms would require too many arbitrary decisions. The technique I developed combines two spectrograms for each sample analyzed. As Figure 3 shows, one spectrogram has the regular broad band and a second one is made using the amplitude contour. Superimposed on the top of each spectrogram there is an oscillographic image. Extensive work done by the author using continuous speech has shown that observations and measurements of sound-segments in continuous speech are made reliably if this technique is used.

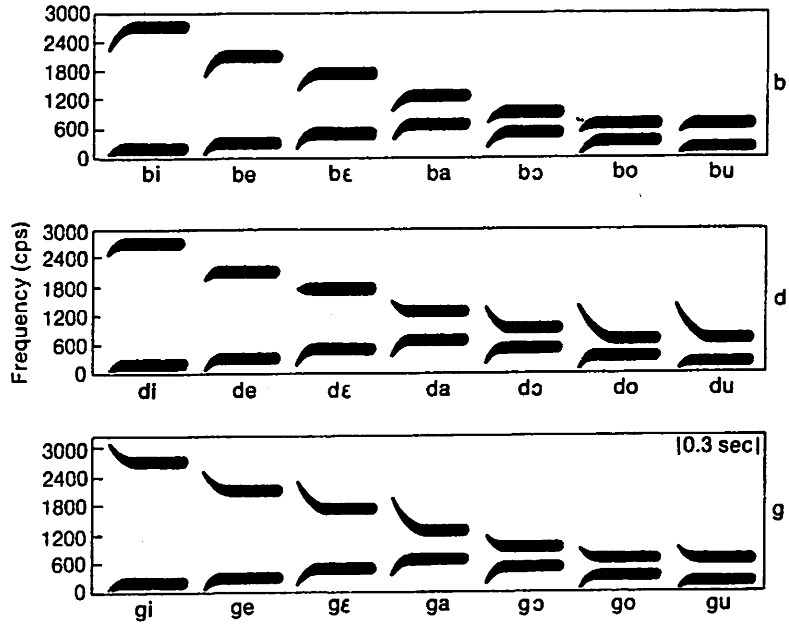
Figure 3: Spectrograms of the sentence "...e arrisca um cumprimento:" (...and she tries to salute:") showing superimposition of different images from the Sona-Graph.



For a clearer image, a high shape range (AGC) was used in making the spectrograms. High shape range prevents amplitude from lowering in high frequencies. One then, should be careful when looking at these figures in the high frequency such as the region of F3 and above. In other words, the use of AGC creates artifacts which highlights information which should be fading in that area. In this study observations were made, at first, based on changes at F1 and F2 domains.

Researchers from the Haskins Laboratory (Delattre and al, 1955) used a set of consonants [b,d,g] in contact with various vowels and found that the formant transitions of F1 and F2 are cues that caused the listener to identify these consonants. In their study it was observed that the formant transition of F2 seemed the most relevant cue to the understanding of these sounds. For this reason the discussions in the present analysis are mostly based on observations done at the first and second formants domains. Figure 11 reproduces their basic results illustrating where F1 and F2 transition movements take place. Chistovich and al (1979) further developed this notion by introducing the notion of "centers of gravity" which represent the combination of both F1 and F2, with the assumption that decoding takes place first on a global perception. This global perception of speech-sounds is in vowels the perception of these centers of gravity.

Figure 4: From Delattre and al (1955) the schematic presentation of synthetic spectrograms showing only F1 and F2 information that produce the voiced stops before various vowels.



Spectrograms, since Liberman and al (1967) paper, have been basically left aside as a useless document for serious linguistic analysis. Cole and al (1980) finally returned some credibility to the use of spectrograms through the use of spectrograms in their analyses. The consequences of spectrograms regaining its position among speech researchers are such that even in state-of-the-art researches such as speech recognition these displays are most helpful. Now, derivation of acoustic correlates directly from spectrogram displays is an important trend in phonetics (Cole and al, 1983).

3.3. Segmentation procedures

Studies of sound-segments are usually done in one of four ways: (1) using isolated sound-segments (Strevens, 1960), (2) using a sentence context (Heinz and Stevens, 1961; Chafcouloff and al, 1976), (3) using both (Jassem, 1965, 1968), and (4) using connected speech in long contexts (Klatt, 1976).

Segmentation of speech-sounds in connected speech is extremely complex. The Sona-Graph remains in my opinion the best instrument for speech analysis, despite the highly "rounded off" measurement we obtain from it. It requires that the same researcher takes all measurements or that manual rules for segmentation be established and kept rigorously under all circumstances.

Klatt's way of segmenting served as the base for my own segmentation rules.[2] Besides Klatt, I had to use the notions of onglides, offglides, steady state, and simple and complex nuclei found in Lehiste and Peterson (1961). The idea of centering visual observations on the second formant region was borrowed from Lieberman (1977), as it will be mentioned as one of the manual segmentation rules.

The manual segmentations are established according to the type of sounds under study, namely, the vowels. The visual cues which allowed quite reliable segmentation using the Digital Kay Sona-Graph are listed below in order of importance. When one procedure did not suffice, we would go to the next or combine two or three procedures. As mentioned above the Digital Kay Sona-

[2] The term "rule" is used here synonymously with "procedure."

Graph can combine an oscillographic image with the usual 3D image which eliminated many problems one has in segmenting. Before any of the rules for manual segmentation below is applied these spectrogram pairings have to be well analyzed qualitatively. This preliminary analysis will allow for a first attempt in locating phonetically realized speech-sounds. Only then, are the rules below to be applied.

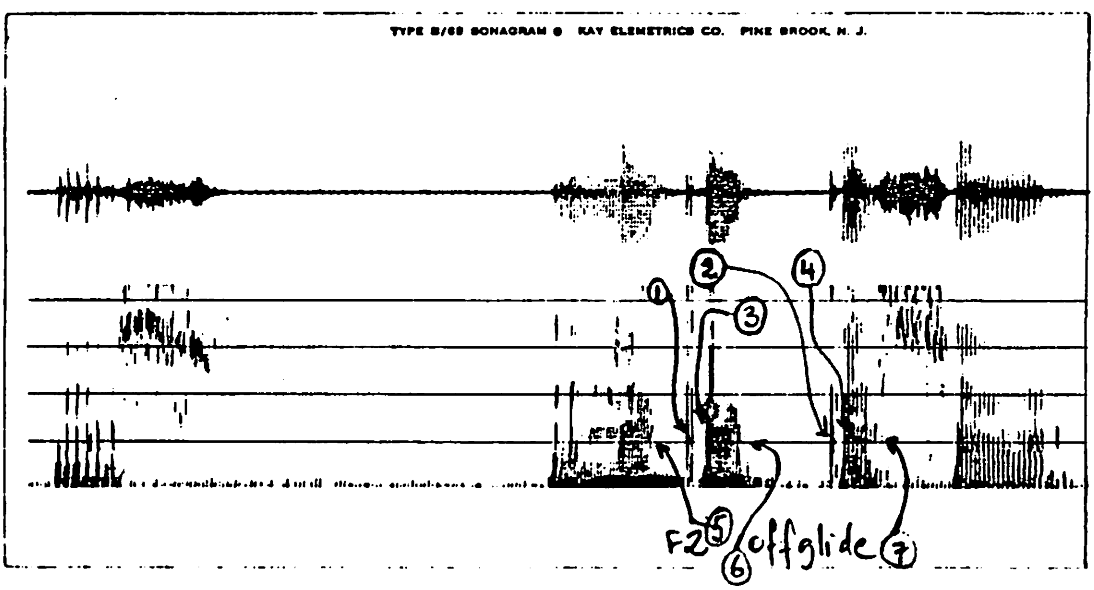
3.4. Rules for manual segmentation

Each of the rules below has a figure illustrating each figure. The rules and each figure are organized as follow:

rule 1	refers to	figure 5
rule 2	refers to	figure 6
rule 3	refers to	figure 7
rule 4	refers to	figure 8
rule 5	refers to	figure 9

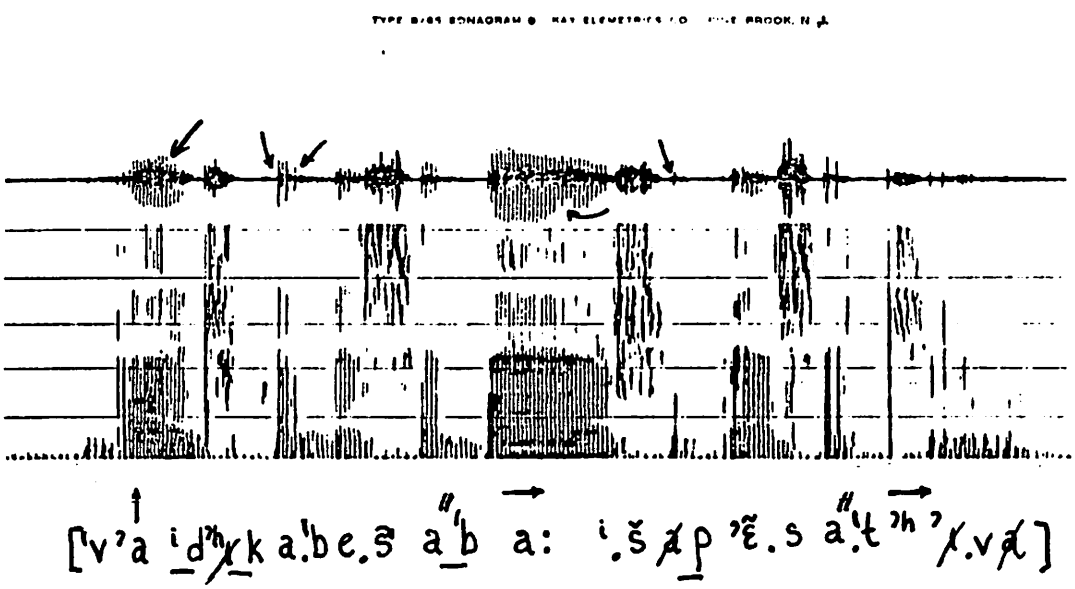
®. *Rule 1.* The point of departure is the onglide and the offglide (Lehiste and Peterson, 1961) of the second formant transition, i.e. when the second formant starts (most of the times preceded by a "blank"), and when it is interrupted. In other words, the whole formant transitions are included as part of the sound to which they belong. In case there is a burst or a glottal stop, the segmentation is done before the burst or glottal stop, still at the F2 level.

Figure 5: Illustration of the point of departure for the manual segmentation process: the onglides and offglides (Lehiste and Peterson, 1961) are to be segmented first. Arrows 1 and 2 indicate bursts at the F2 region since bursts and glottal stops are segmented as part of the following segment; arrows 3,4 indicate F2 onsets; and arrows 5,6,7 show F2 offglides.



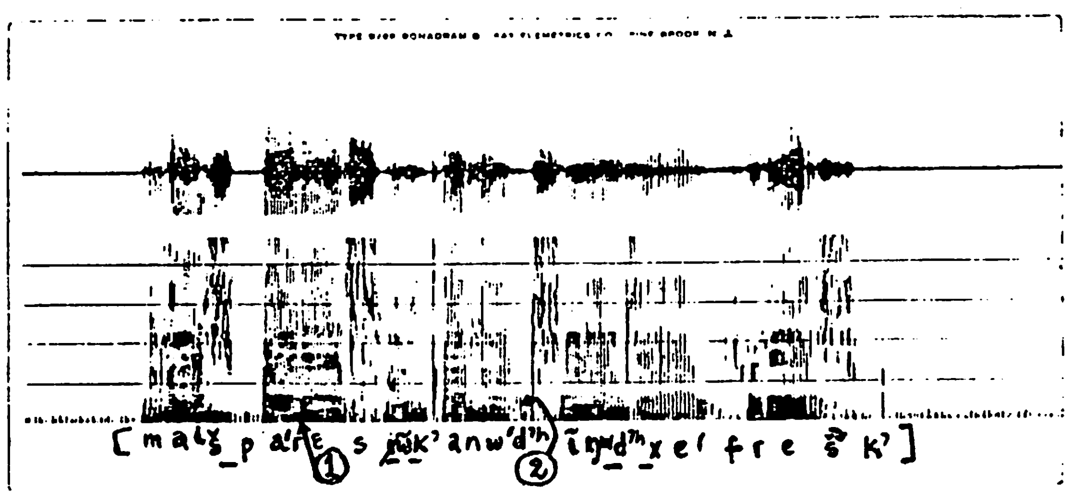
®. *Rule 2.* Use the waveform information provided by a superimposed oscillograph built in the Digital Sona-Graph. This sound wave image shows clear variations when the glottal pulses (vertical spikes) shorten vertically to become almost confused with the zero lines. Such variations are indicative of the end of a sound-segment and/or the beginning of another. This is a consequence of damped oscillations. Any other sudden change in the amplitude of these soundwave images are potential indicators of sound boundaries, although these sudden changes are observed outside the zero line region.

Figure 6: The superimposed oscillograph image is mandatory in analyses using continuous speech. The document illustrates the sentence "Vai de cabeça baixa, pensativa" with sudden changes in the superimposed oscillagraphic image, indicative of sound segment boundary. The five arrows in the figure below point to phoneme boundaries in the oscillographic image.



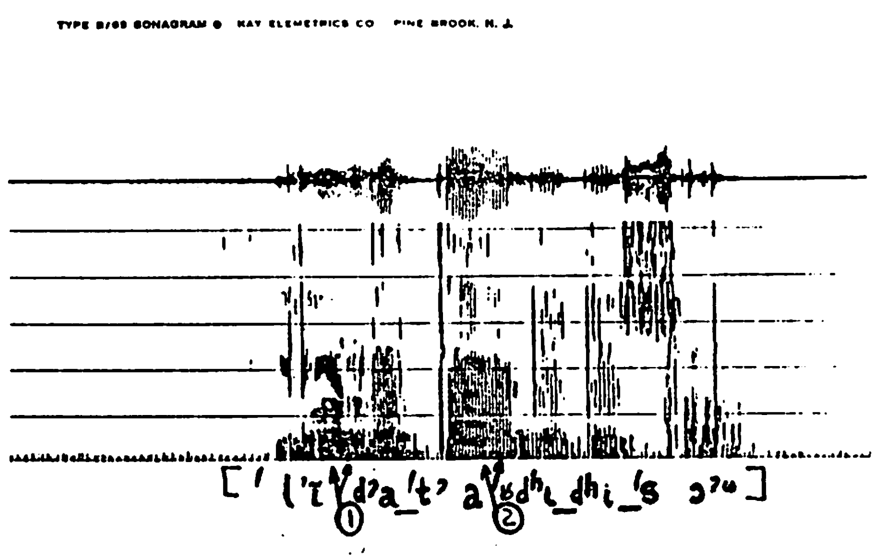
®. *Rule 3.* Observe the changes in the relative intensity in the first formant region, reflected in the darkening of images. Any change in energy concentration might indicate a new sound. It is known that true consonants have less energy than true vowels. In terms of sound relative intensity (reflected in the darkening differences on the spectrogram), consonants have less intensity than vowels. This may be explained by the production of both classes of sounds. Vowels find no obstacle in their way out of the vocal tract and is realized with most of its energy from the glottal source. On the other hand, consonants are completely or partially obstrued in their realization creating a loss of energy.

Figure 7: The differences in the relative intensity of speech-sounds in the region of the first formants. Consonants are characterized by weaker energy (less darkening in the spectrograms) than vowels. Arrow 1 points the less darkened image of the liquid [r] in between the darker images of [a] and [ɛ] in the word [pa'.ɾɛ.sɣ] "parece" ("looks like"); arrow 2 shows [d] less darkened than the preceding [ω] in [ka.nω.'dʰĩ.ηω], "canudinho" ("little straw").



®. *Rule 4.* Take into consideration the lowering or rising of the fundamental frequency observed through spikes spacement (glottal pulses). Lowering of the Fo (fundamental frequency) happens when, relative to the glottal pulses of the preceding adjacent sound-segment, the glottal pulses are more apart; in rising of the Fo glottal pulses are closer, relative to the glottal pulses of the preceding adjacent sound-segment.

Figure 8: Spectrogram showing how rule 4 is to be applied. The arrows, as above, indicate the points described. Double-arrow 1 indicates pulses, on the left branching of it, closer (higher Fo) than on the right branching; double-arrow 2 shows a similar example with the left branching indicating rising of Fo, and the right branching lowering of Fo.



®. *Rule 5.* As Klatt (1975) suggested, the burst characteristic of stop consonants, is considered as part of the following sound-segment, not as part of the stop. This is helpful in treating vowel segmentation when vowels are not preceded by stop consonants. The spectrograms in this study show that a glottal stop (visually similar to a burst) precedes all vowels most of the times, especially the front low [a]. In addition, liquids are also preceded by a glottal stop. Finally, any aspiration, including that associated with palatalization is included in the vowel portion.

Figure 9A: Klatt's (1975) method for segmentation. This method is repeated in the present study as Figure 9B shows for comparison with Figure 9A.

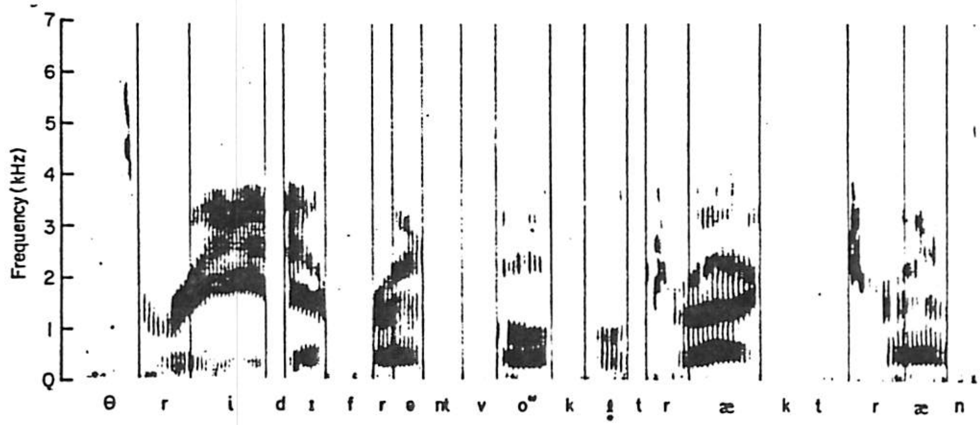
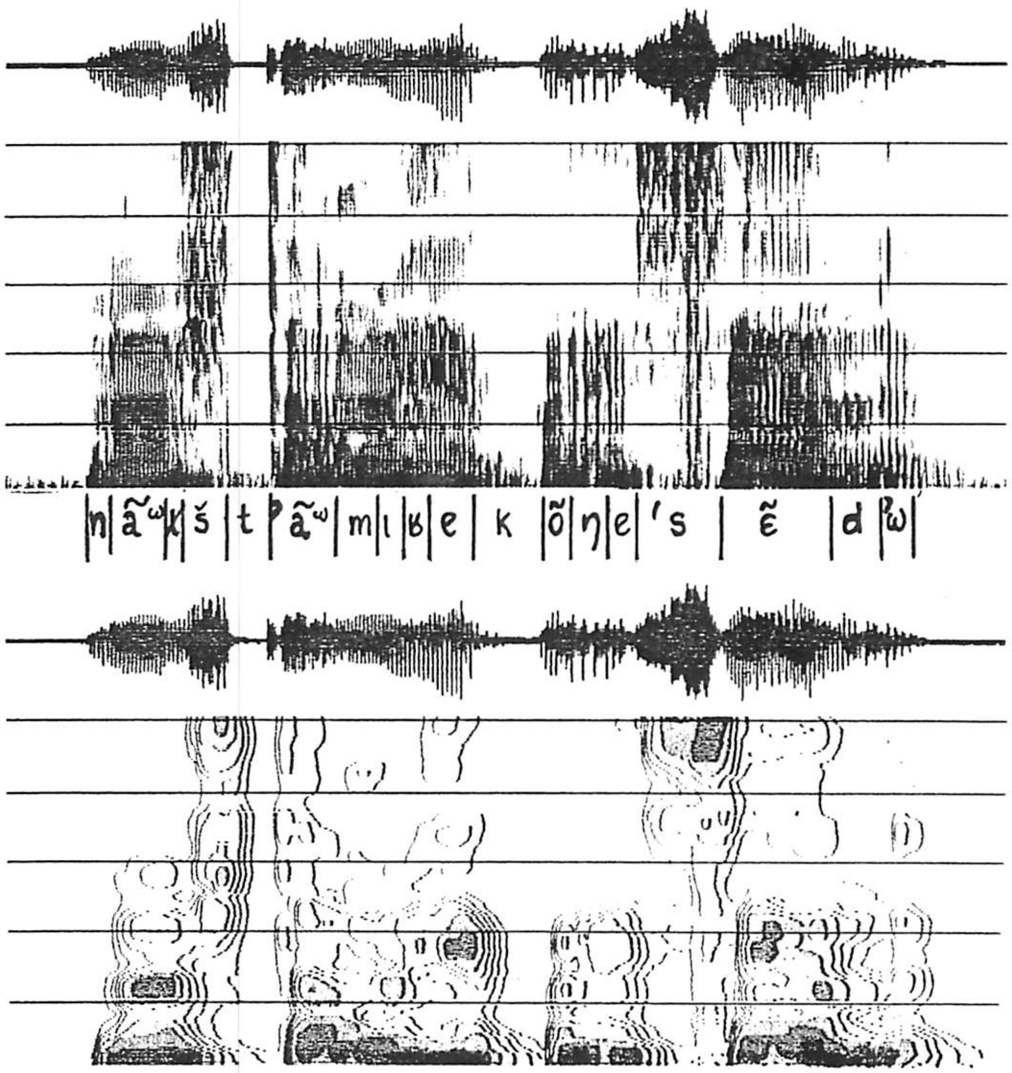


Figure 1 A broad-band spectrogram is shown of the sentence fragment "Three different vocal tract tran(sfer) . . .". Vertical lines have been drawn at segment boundaries according to criteria defined in the text.

Figure 9B: An example of the segmentation done in the present study. The segmentation of the continuous speech of the speaker in this study is reliable only if both images using the regular 3D and the amplitude contour are superimposed.



The rules above should suffice for manual segmentation. However, in case there are doubts, there is secondary information that can be used, as follows. In the high frequency regions, namely regions above 4 kHz, there is usually a clear distinction between vowels and consonants. The formant structure of vowels may show four formants. The fourth formant gives information about the limits between two adjacent vowels in different words, e.g. the two "**a**"s in

"chamar **a** atenção,"

when they happen to be apart. Also the anti-resonance characteristic of nasals can sometimes be used as a cue in separating the vowel portion from adjacent nasals.

3.5. Data analysis

3.5.1. Factors Studied

Following are examples of the procedures taken in analyzing the data obtained in this study. The examples from appendix __ illustrate how the significant values were interpreted. As is shown, sound segment patterns reflect the operation of linguistic components at precise points.

To list and study all factors influencing duration patterns in speech is beyond the scope of this research. It is premature to attempt a study which also includes physiological, discourse, and extralinguistic factors, to mention some. This study covers (1) the phonological and the phonetic domain, (2) the word domain, (3) the syntactic domain and (4) the semantic domain. As one can see multiple factors operate in reducing and expanding sound-segment duration.

Sentences having one or more factors operating significantly: REDUCTION.

3. Caro"'lin[a0.][3] , a mi"'nhoca,

[3] The numbers on the left margin correspond to the numbers in appendices 2-4. There are many cases of complete reductions in this study. Values of 0.0 (zero) and 1.0 are assigned to them so that they are recorded. It is premature to attempt a full analysis of these complete reductions, and they are discussed only when applicable.

FACTORS OPERATING:

phonology: posttonic final position (word domain), unstressed; *rhythm*, immediately after a rhythmic foot; *intonation*, the [a] is in the minimum of a curve. In English a glottal stop would be inserted between two vowels ending and starting words.

phonetics: unstressed vowel having phonetic identity with the following vowel, due to a linking caused by the lack of an expected pause

4. "'tem "'dois "'grandes des"'gostos na "'vid[a1.]

FACTORS OPERATING:

phonology: postonic final position (word domain), unstressed; *rhythm*, immediately following a rhythmic foot; *intonation*, immediate syllable after a falling contour.

Sentences having one or more factors operating

significantly: EXPANSION.

5. -- ser c[a17.5]"'reca

FACTOR OPERATING:

semantics: focusing after copula verb

39. C[a19.]ru"'lina, amuada,

FACTORS OPERATING:

phonology: word initial position preceded by a consonant, pr3 position; *intonation*, rising contour at the beginning of a sentence.

phonetics: the vowel [a] is inherently strong in energy.

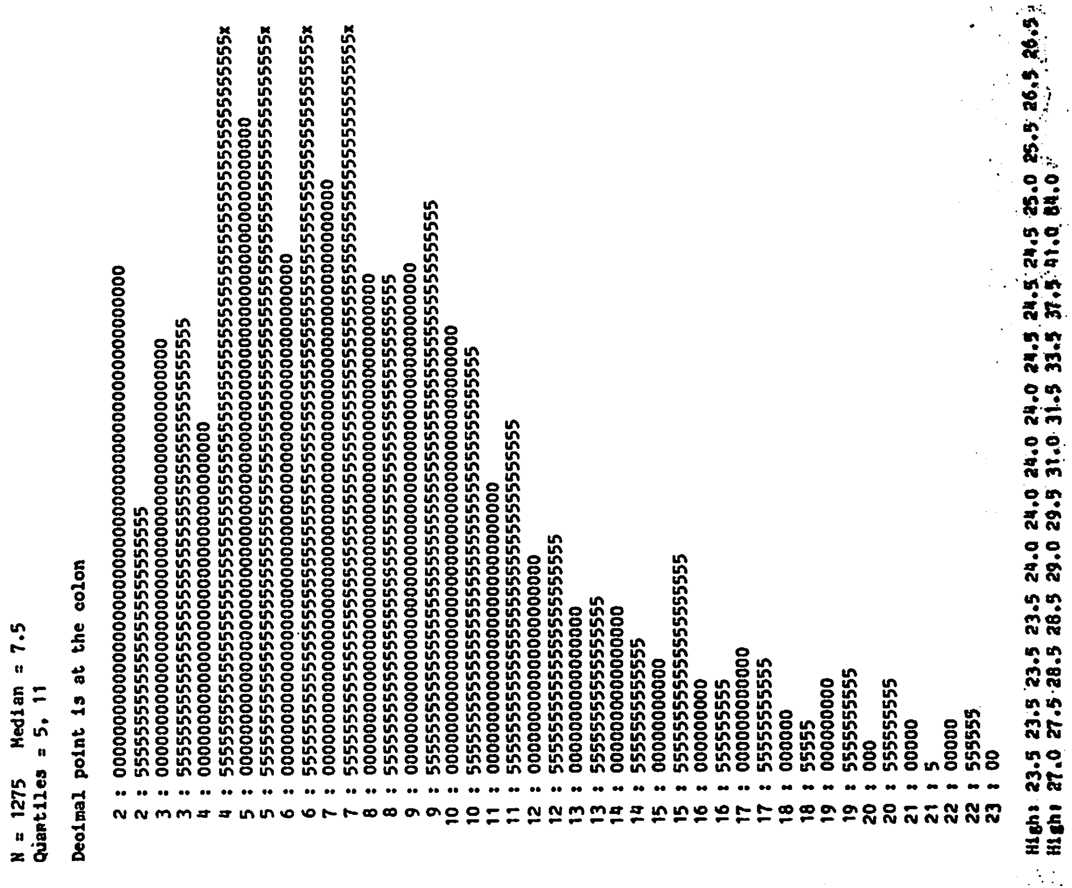
3.5.2. Statistical techniques

The S Statistical Package, implemented in the UNIX operating system (Unix is a trademark of Bell Laboratories), and run on a Digital Equipment Corporation VAX 11/780 at the UT Austin campus was used for most of processing and graphics. The analysis of variance used here is a local program (ANOVA8) which is based on the PMDP series. It was developed by Thain Marston, a graduate student in Experimental Psychology at UT Austin.

Analysis of all data from these vowels in the corpus consistently shows functions positively skewed (Figure 10, p. 58), that is lower values concentrate on the left side of the horizontal axis (abscissa), in such a way that higher values will spread rightward. A parameter such as duration is expected to be positively skewed. This distribution is the reason the median was chosen as the measurement type for this parameter, instead of the mean. Observations of the behavior of these functions led to the definition of unmarked ("inherent") duration as given in the first and second chapters (pp. 14 and 32ff). This is a definition which is quite objective and has not previously been proposed. Former definitions of unmarked values are not disregarded. They are all valid and have already been proven useful. My proposition allows for researchers without access to various instruments to establish intrinsic values in an experimentally valid manner. Besides, the median gives an impartial decision which does not depend on previous knowledge of the speech under analysis. The use of the longest "inherent" duration (Klatt, 1976; Lindblom and al 1981), for example is not possible in CV languages since it requires the use of CVC monosyllables in establishing the "inherent" longest duration for vowels (cf. discussion in Chapter 5).

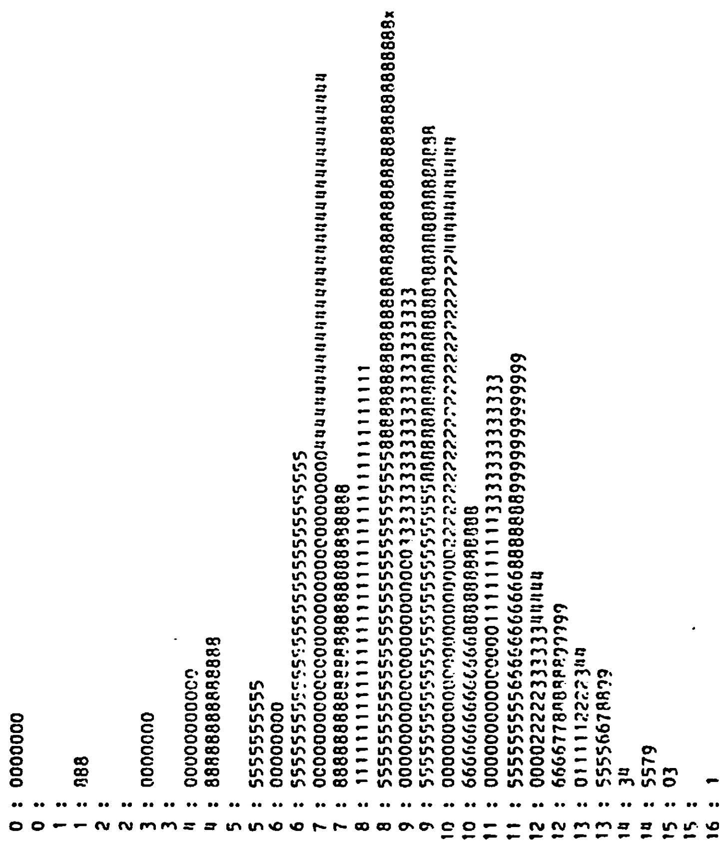
In Figure 10 a common pattern of the data is shown. Observe that the values of measurements of duration tend to cluster on the left side of the abcissa. Without considering yet factors such as stress and position, a first look into this curve can be done in any of the two approaches. One approach examines values falling after a given number of standard deviations (2 or 3 standard deviations). Values in these areas outside 2 or 3 standard deviations indicate sound segment durations that are statistically significant. The second approach analyzes values falling outside the quartiles of the distribution. The second approach is simpler because the statistical program used here lists the statistically significant data according to the quartiles leaving the user free from calculating standard deviations.

Figure 10: As expected from a parameter like duration, the data shows a pattern of distribution which is positively skewed. Quartiles and high values are indicated.



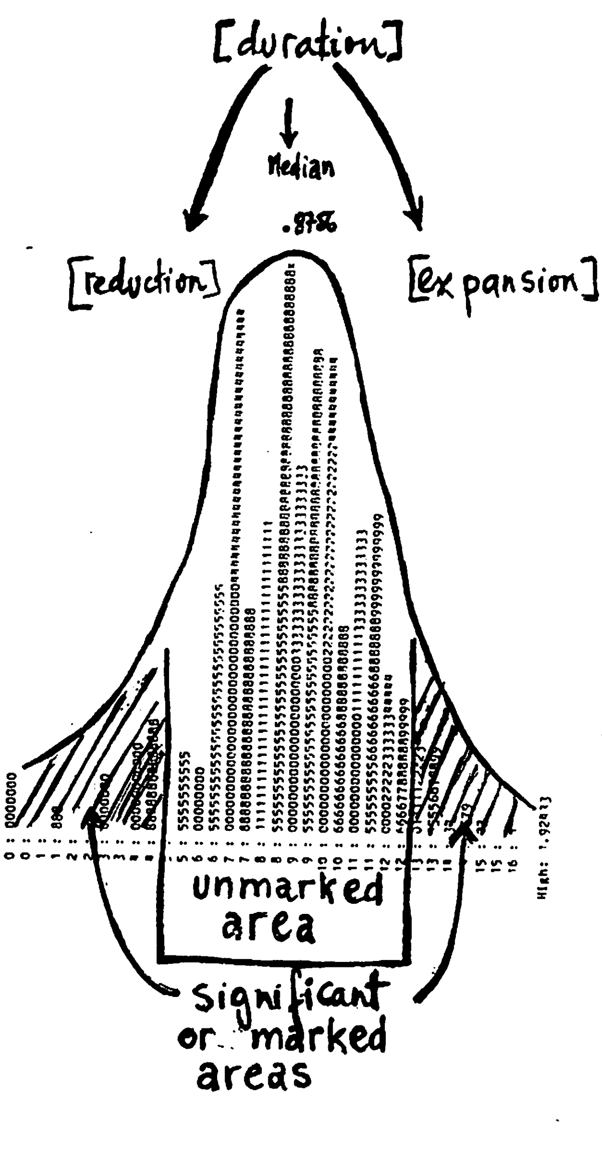
Considering the approach using standard deviations, values falling on the left side of the median (the inherent duration) are difficult to handle because they cannot fall below the 0.0 value. They are thus biased in this curve because of the nature of the phenomenon duration. Some possibilities have to be considered in these cases. Maybe only one or one and a half standard deviations are to be taken as cutoff point, instead of two or three as it is done usually with a normal curve. This can bias the research since subjective decisions may take place. A more applicable solution would be to take a common logarithm of these positively skewed distribution and transform them into a normal distribution. This was done as we see in Figure 11.

Figure 11: A positively skewed distribution like the one in Figure 10 becomes a normal distribution after the common logarithm of the data is taken.



The values detected as statistically significant on the right side will serve as a reference point. Suppose the values ≥ 18.0 cm (144ms) are shown as statistically significant. Then the logarithm of 18.0 gives the cutoff line on the left side of the now normalized curve as illustrated by Figure 12.

Figure 12: A typical analysis done on a normalized curve like the one in Figure 10.



This allows for separating values which are simply expected values of these vowels from values which appear in the furthermost areas of the curve ("curve tail"). The values falling in the statistically important areas are the ones of interest and the ones that need explanations as to why are they falling far off the norm. It may be that a syntactic component is making some vowels longer, it may come from melodic curves, from the phonological component, from the three of them and so on.

A step further in this approach combines general linguistic knowledge with experimental research, although extremely difficult to handle, should provide for a finer and more elegant suggestion as to what is happening in the speech chain. The next section concentrates on this aspect of the methodology used here.

Establishing stress groups

Once the two classes of inherently stressed and unstressed words are properly assigned (see Chapter 2, page __), decisions are made about which syllables are pretonic (pr1, pr2, pr3, ...) or postonic (post1, post2, post3, ...), according to the main stress (+stress). Considering, for example, a sentence like

1. Caro"'lina, a mi"'nhoca, "'tem "'dois "'grandes des"'gostos na "'vida -- ser ca"'reca e 'não 'ter cin"'tura.

The breakdown is shown in Figure 13:

Figure 13: Sentence breakdown in stressed and unstressed groups. This example uses the sentence "Carolina, a minhoca, tem dois grandes desgostos na vida -- ser careca e não ter cintura," (Carolina, the worm, has two big misfortunes -- to be bald and to lack a waist-line.")

(...)pr3	pr2	pr1	+STRESS	post1	post2 (...)
	Ca	ro	li	na,	
	a	mi	nho	ca,	
				tem	
				dois	
				gran	des
			des	gos	tos
			na	vi	da
		ser	ca	re	ca
			e	não	
				ter	
			cin	tu	ra.

Once stressed and unstressed words were classified, syllables were classified according to their pretonicity and postonicity. Figure 14 illustrates this:

Figure 14: An example of how stressed and unstressed groups were classified inside the whole noun phrase.

Convention:

pr1 - pretonic
pr2 - pre-pretonic
pr3 - pre-pre-pretonic
etc.

post1 - postonic
post2 - postpostonic
post3 - post-postpostonic

VOWEL [a]

	pr4 [-stressed]	pr3 [-stressed]	pr2 [-stressed]	pr1 [-stressed]	[STRESSED]	post1 [-stressed]	post2 [-stressed]	post3 [-stressed]
18.		7.5	9.0	6.5		3.0		
						0.5		
19.				6.5	15.0	3.0		
					17.0	2.0		
20.			7.5	6.0		5.5		
						3.0		
21.		6.5		10.0	7.0	9.0		
		6.0				9.0		

Taking the opportunity of the great number of measurements taken for this corpus, these groupings were treated the same way above, namely the behavior of their functions was observed individually and then normalized with their common logarithm. Then other techniques of analysis could be used according to the goals. For example, analysis of variance was applied, in an attempt to find empirical support to the hypothesis that phonological processes operate at a given hierarchy, namely from postonic to both pretonics and to stressed positions.

3.6. A first approach to rhythm and intonation patterns

Rhythm was studied by informally giving to both naïve and experienced subjects the tape of the story recorded by PM. The subjects made their judgments on sentence level stress by means of written and spoken text given to them. They were asked to detect "beats" (melodic stress) in *fluent speech* after an explanation was provided to them. They were told what a melodic stress was (Ladefoged, 1975; Landercy and Renard, 1977) and then they were trained using English and BP texts to detect melodic stress. Their judgements varied. My work was to select the coinciding judgements and take my own decision on where a beat was given whenever disagreement occurred.

Intonation patterns were obtained by first taking countings of glottal pulses on the spectrograms at points of interest in the spoken text. The points of interest for the present study are, at the sentence level, beginning, medial and final positions. Decisions on contour configurations such as raising, falling and neutrality of the fundamental frequency were based on comparison of preceding pulse patterns with the pulses seen at a stressed speech-sound with formant structure (usually vowels). Afterward it proved helpful to listen to the recordings to validate these decisions.

All the procedures set forth above, have been followed rigorously and tested preliminarily before definitive application on this work.

3.7. Summary of chapter 3

The experimental protocol presented in this chapter shows in the first section how the recordings took place, the production of spectrograms, and segmentation of speech. The second section contains the analysis of the data.

The recordings were made in two sessions in order to have the speaker well familiarized with the text he read. The production of spectrograms is the usual one done in phonetic laboratories. The difference in continuous speech necessitates the use of superimposed displays containing 3D, oscillographic and amplitude contour images. The superimposition of displays for reliable analysis of continuous speech is a technique developed for the present investigation. The segmentation procedures have specific rules that stem mainly from observations collected in the works of Lehiste and Peterson (1961), Klatt (1975), and Lieberman (1977).

The second part of the chapter explains the data analysis. As expected, duration shows data with positively skewed distribution. A common logarithm of these functions is taken, and then standard deviations are used to separate statistically significant data from normal data.

This chapter uses the concepts of inherent duration developed in the preceding chapter to establish stress groups: pretonic and postonic in relation to the stressed syllable. The last section shows how rhythm and intonation are studied in this research. Subjects listened to the recordings and attempted to detect "beats" for rhythm. The intonation patterns were studied by counting glottal pulses of sound segments adjacents. In other words, glottal pulses variations were compared at each point of interest. This procedure allowed for a first proposition on intonation patterns for the speaker of the present study.

Chapter 4. Results

4.0. Introduction

The results discussed here were obtained by following strictly the experimental protocol described in Chapter 3. The presentation of the results follows the same format that has been used in the preceding chapters: (1) results from the phonological and phonetic domain, (2) word domain, (3) sentence (syntactic) domain, and (4) semantic domain. Results from other domains or factors such as discourse analysis, extralinguistic, and so forth are not presented here. For more details about the data, the appendices contain all measurements taken with the distribution of each vowel according to each situation studied (appendix 4), and all measurements inserted in each position the vowels appear in the text (appendix 2). As appendix 4 shows, the distribution of all situations are positively skewed, i.e. most values (lower values) concentrate around the left side of the abcissa and the rest of values, as they become greater they spread out rightward.

4.1. The factors studied: phonology/phonetics, word, sentence, and semantics

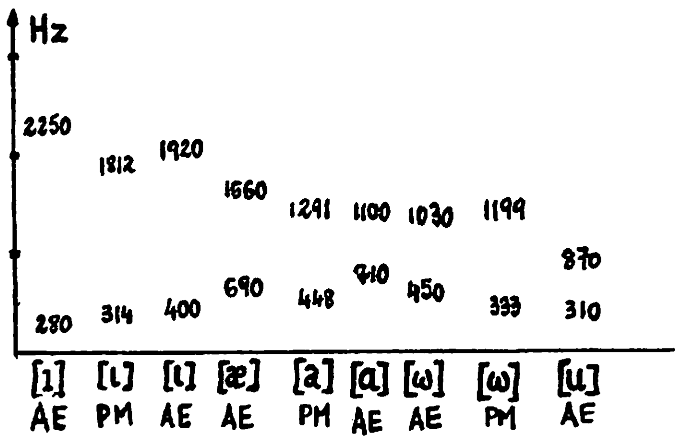
4.1.1. Phonological and phonetic factors

4.1.1.1. *Acoustic chart of the vowels studied:* /i/, /a/, /u/

From phonological descriptions of BP it would be expected that the three vowels studied had their phonetic quality similar to the vowels [i,a,u]. However, as depicted in Figure 15, in accordance with their formant structure, the three extreme vowels in the speech of PM, the speaker analyzed, are better symbolized as [ɩ,a,ω] if one takes as reference the usual acoustic charts for English (Ladefoged, 1975, 170ff). An interpretation of the acoustic quality (formant patterns) of these vowels and the effect of vowel quality upon duration is presented in the next chapter.

The three vowels have their acoustic quality as follows. The front high vowel [ɩ] has its frequency of F1 around 314 Hz and F2 around 1812 Hz. This indicates an F1 higher in frequency than American English [i] as in "heed" (see figure 15 for these comparisons), and [ɩ] as in "hid." The frequency of F2 in PM's [ɩ] indicates that it is lower than the F2 of [i] and higher than the F2 of [ɩ] in American English. The front, low [a] (see Câmara, 1977, 58), has its F1 around 448 Hz and F2 around 1291 Hz. American English has no corresponding vowels for PM's [a]. In terms of F2 values, *viz.* in terms of articulatory phonetics, fronting and backing tongue movements (Fant, 1970), PM's [a] is found to be between American English front, low, lax [ae] as in "bag" and back, low [*a*] as in "hod." The F1 and F2 of the high, back [ω] in PM's speech is around 333 Hz and 1199 Hz. In acoustic terms (F1 and F2 patterns) PM's [ω] is closer to American English high, back, lax [ω] as in "good," but it also shares some characteristics with the high, back, tense [u] as in "who." From their frequency values the vowel [ω] in PM's speech is, in terms of opening and backing, between American English [ω] and [u].

Figure 15: Acoustic chart of the three vowels [ɩ, a, ɷ] analyzed (BP) in this study compared to American English (AE) closest ones. American English vowels are excised from carrier sentences (Ladefoged, 1975, 166). PM's vowels are from continuous speech. The vowels are plotted according to the frequency of the two first formants.



4.1.1.2. *Unmarked vowel duration*

The unmarked (inherent or intrinsic) values are obtained from the grand median, namely all stressed and unstressed positions. The results show that this speaker's vowels have unmarked values (grand median), as follows:

[ɩ,a,ɷ]	60 msec (7.5 mm)	1275 items
[ɩ]	56 msec (7.0 mm)	379 items
[a]	64 msec (8.0 mm)	636 items
[ɷ]	48 msec (6.0 mm)	260 items

Measurements in stressed and unstressed positions of the vowels of the speaker of BP are as follows:

Vowel	[STRESSED]	items	[UNSTRESSED]	items
[ɩ,a,ω]	120ms	239	52ms	1036
[ɩ]	108ms	78	48ms	301
[a]	120ms	126	60ms	510
[ω]	112ms	35	44ms	225

The grand medians of each vowel individually are used to find the minimum duration of each vowel and to initialize (rule 1) the rules proposed in chapter 5. The pairs of stressed and unstressed vowel durations are used as evidence in some aspects of the discussion, e.g. rhythm pattern.

4.1.1.3. *Effects of postvocalic consonant*

In the phonotactics of BP only three consonants appear in final position: /S/, /l/, and /r/. Phonetically /l/ always vocalizes as a semi vowel [ω]. The liquid /l/ then cannot be used in the analysis. Of these three consonants /S/ and /r/ have a frequency of occurrence amenable to analysis. Vowels in any position in this study are clearly undergoing reduction when followed by a phonetic realization of /S/, i.e. a voiceless palato-alveolar fricative [š] and in a less extent when followed by one of the phonetic realizations of /x/, namely a voiceless velar fricative [x]. For example in both pretonic positions, the vowel [ɩ] has a range of significant reduction from 40-100 percent, i.e. up to complete reduction. More precisely, an [ɩ] followed by [š] in pr2 position ("esqui'sita," "espar'tilho," etc.) varies from 40-100 percent; an [ɩ] followed by [š] in pr1 position ("deses'pero, "ex'plode," etc.) is less affected: 40-80 percent reduction.

The fortis consonant /r/ (see Câmara, 1977) varies depending on the dialect of BP. In the case of PM the voiceless fricative /x/ is to be assigned. Although it is attempted here to make generalizations about PM's /x/, unpredictable alternations between fricative [x] and approximant [ɓ̣] were observed. Similarly, in word final position, /x/ is realized as [x] or [Ø] (zero). Word final position seems to be a situation influenced by the written text. The retelling of the story, a part of the present investigation that could not be included, shows a systematic deletion of /x/ in word final position. Bearing in mind these observations, it can be said that /x/ (fortis /r/) has shown four phonetic realizations phonologically controlled: (1) voiced [x] in intervocalic position, (2) voiced [x] before a voiced consonant, although the following consonant is in the next syllable, (3) voiceless [x] before a voiceless consonant and (4) tap [r] in linking. The lateral realization of /x/ has in PM's speech the characteristic of the approximant [ɓ] (Ladefoged, 1975). In the present study the liquid realization of /x/, i.e. [r], and the voiced realizations of /x/, i.e. [x] and [ɓ], have not shown any significant effect on the duration of the preceding vowel. Syllable final voiceless [x] reduces the preceding vowel in 20-30% in both stressed and unstressed positions. This is a smaller reduction than the reduction observed in the case of [š].

4.1.1.4. *Intonation patterns*

The intonation patterns for this speaker can be generalized in declarative sentences because declarative sentences make up most of sentence types, and the intonation patterns in the case of declarative sentences are very systematic:

[RISING Fo ({moderate rising OR flat Fo} / rising Fo) Ø-∞ FALLING Fo]

The square brakets ([ ]) represent the beginning and the end of any sentence: simple or complex. The parentheses include optional sentence structures that can be added or not. In case there is a simple sentence, the sentence starts with a rising contour and ends in a falling contour. Complex sentences have their beginning and end with the same pattern: rising then falling. Inside a complex sentence, the embedded sentences start with either a moderate rising or a flat contour; the embedded sentences always end in a rising contour. A falling contour is an indication of the end of the whole sentence. The described pattern is valid for the speaker analyzed in this study.

4.2. Word factors

This sections summarizes the results according to word position. Table 2 provides the global values (grand median of the three vowels [ι, a, ω] altogether). In Table 2 the same vowels are shown individually.

Table 2: Medians of the vowels [ɩ, a, ω] according to their positions in the word. The following abreviations are used: all (all positions), stressed (stressed position), non-stressed (non-stressed positions pr2, pr1 and post1), pr2 (pretonic position, second from stressed), pr1 (pretonic position, immediate to stressed), post1 (postonic position), and others (other non-stressed positions).

Word factors according to the vowels [ɩ, a, ω]		
Position	Global values: [ɩ, a, ω]	
all	60 ms (7.5 mm)	1275 items*
stressed	120 ms (15.0 mm)	239 items
non-stressed	52 ms (6.5 mm)	1036 items
pr2	56 ms (7.0 mm)	186 items
pr1	64 ms (8.0 mm)	341 items
post1	44 ms (5.5 mm)	391 items
others	48 ms (6.0 mm)	118 items

(*)One would expect 1423 items as mentioned above. Complete reductions, although they are studied and given values 0.0 ms and 1.0 ms, they are not included in the results here.

Table 3: Medians of the vowels [ɩ, a, ω] taken individually. The abbreviations are the same as in Table 2.

Word factors according to the vowels [ɩ, a, ω]			
Position	Individual values		
	[ɩ]	[a]	[ω]
all	56 ms (7.0 mm) 379 items	64 ms (8.0 mm) 636 items	48 ms (6.0 mm) 260 items
stressed	108 ms (13.5 mm) 78 items	120 ms (15.0 mm) 126 items	112 ms (14.0 mm) 35 items
non-stressed	48 ms (6.0 mm) 301 items	60 ms (7.5 mm) 510 items	44 ms (5.5 mm) 225 items
pr2	44 ms (5.5 mm) 74 items	64 ms (8.0 mm) 90 items	44 ms (5.5 mm) 22 items
pr1	52 ms (6.5 mm) 127 items	72 ms (9.0 mm) 145 items	64 ms (8.0 mm) 69 items
post1	48 ms (6.0 mm) 50 items	48 ms (6.0 mm) 235 items	28 ms (3.5 mm) 106 items
others	44 ms (5.5 mm) 50 items	56 ms (7.0 mm) 40 items	42 ms (5.25 mm) 28 items

4.2.1. *Duration according to relative position in the word*

Considering the following word organization:

... pretonic 2 # pretonic 1 # STRESSED # postonic 1 ...

this Brazilian speaker's recording shows the following order of magnitude in duration in word position:

post1 > pr1 > pr2 (consonant initial) > STRESSED[4]

Analysis of variance shows that these groups have significant inter-group relation. The results are as follows:

Vowel [a]

MEAN	MEAN	DF	Q	.05	.01	VALUE
stressed	post1	524	23.6217	3.69	4.5	-
stressed	pr2	524	17.9942	3.36	4.2	-
stressed	pr1	524	16.6873	2.80	3.70	-
pr1	post1	524	6.93443	3.36	4.20	-
pr1	pr2	524	1.30689	2.80	3.70	non-sign
pr2	post1	524	5.62754	2.80	3.70	-

[4] The syllabic patterns of both types of pretonic is discussed on p. 92.

Vowel [ɩ]

MEAN	MEAN	DF	Q	.05	.01	VALUE
stressed	post1	288	14.5321	3.69	4.5	-
stressed	pr2	288	14.4141	3.36	4.2	-
stressed	pr1	288	14.1854	2.80	3.70	-
pr1	post1	288	.346757	3.36	4.20	non-sign
pr1	pr2	288	.228692	2.80	3.70	non-sign
pr2	post1	288	.118065	2.80	3.70	non-sign

Vowel [ω]

MEAN	MEAN	DF	Q	.05	.01	VALUE
stressed	post1	156	18.9432	3.69	4.5	-
stressed	pr2	156	18.2397	3.36	4.2	-
stressed	pr1	156	12.2805	2.80	3.70	-
pr1	post1	156	6.66268	3.36	4.20	-
pr1	pr2	156	5.95918	2.80	3.70	-
pr2	post1	156	.703496	2.80	3.70	non-sign

Interpretation of statistical results can only be done in relation to the methodology used in obtaining the data. There are other analyses that have to be pursued. Here a first picture of the object is depicted. The data and the results tell that the non-significant difference between pr2 and pr1 may be due to the segmentation method used (see Chapter 3, pp. 46ff) as well as the non inclusion of a pretonic group having a consonant at the syllable onset. In fact, having a pretonic group pr2 with a consonant at the syllable onset causes a highly significant difference between both medians (pr2 vs pr1) not present in the results above (see next page). For this reason the rules proposed in Chapter 5 reflect this difference in the two kinds of pretonic.

After analysis of variance and further numerical analysis had been applied at the acoustical level of each of the four groups by position, data was processed to establish values for K (equation (1)) in each of the groups. This has been done according to the data presented below. The results come from the whole noun phrase and not from the isolated lexically stressed word. Their purpose is to establish numerically their relative importance. The measurements (median) are in milliseconds.

[a]: 617 items (including pr2 from noun phrases)

	STRESS	pr2	pr1	post1
items	126	90	146	255
median	120.	64	72	48
s.d.	66.64	28.16	30.8	28.64
quartiles	96	58	56	36
quartiles	156	84	88	60

If only pr2 from inside the head element in a phrase is included, there are 51 items instead of 90 above. The median becomes equal to 9.5 (76 ms), the standard deviation becomes 3.85 (30.8) and the quartiles show a larger variation of 7.5 (60 ms) and 13.5 (108 ms). Increasing the number of items would help towards a better reliability. Up to this point the results and analysis of the corpus suggest that pretonic word initial (pr2) is more strengthened than pretonic word medial (pr1). Word position pr2 has a median of 88 ms if preceded by a consonant, but a median of 58 ms if the syllable starts with a vowel. Thus, at the word domain one can assign three constant values to increase or decrease these vowels' unmarked durations. These constants are obtained in the same manner mentioned Chapter 5, viz. by applying equation (2). The unmarked value for vowel [a] is 8.0 mm (64 ms). The minimum value (compressibility) for the same vowel is 5.6 (44.8 ms), because of the decreasing factor of .7. This factor of has been one of the difficulties in the present work.

The choice of .7 for shortening was taken after observing the normalized distributions of the data (see appendix 4) and the specific reductive processes of BP reflected in PM's speech.

Pretonic (pr2)	= 2.4, if consonant initial (42% increase)
Pretonic (pr1)	= 1.43 (13% increase)
Stressed	= 4.0 (90% increase)
Postonic	= 0.17 (25% decrease)

These constants accurately predict an output for duration only if used in the linear equation (1). *K* values differ largely from Klatt's (1976) because of the method. Here no perceptual tests were performed and the value of *K* was obtained by deriving equation (2). Minimum duration is expected to change after perceptual tests are used. Of course, as minimum durations change the values of *K* also change.

4.3. Sentence (syntactic) factors

Following Klatt's criterion (1975) it was determined which segments were greater than 1.4 times the median duration of the segment studied. Values that fall after this cutoff point are segments indicative of important changes which in this case, indicates syntactic boundaries. Then it was established for significant shortening the cutoff point is 0.7 times the median (see discussion above). Only stressed vowels at the end of a sentence are used. The results are as follows:

	[ɩ]	[a]	[ω]
no. items	16	17	9
lengthening	12	15	7
shortening	3	1	2
none	1	1	0

These three vowels show an average (median) increase of 24 msec (20% increase), *viz.* $K = 1.67$, in sentence final position. Measurements of stressed [a] before all pauses, not only the ones in sentence final position, show a greater lengthening of 38.4 msec (32% increase), *viz.* $K = 2.07$.

From Klatt (1976, 1211) one reads "prepausal lengthening also seems to occur at phrase and clause boundaries when there is no physical pause present in the acoustic signal." Using the three vowels studied, four points at the sentence domain are studied in an attempt to confirm this idea. Again, a lengthening factor of 1.4 is used as cutoff point. Klatt (1975) explored syntactic points such as the boundary between a noun phrase and a verb phrase, the end of a sentence, before a conjunction, between a noun and a dangling prepositional phrase, between a noun and a modifying prepositional phrase, and before an embedded clause. The present analysis looks at a word before the following syntactic points: embedded sentences, independent sentences, non-restricted clauses, and before noun phrases heading complex embeddings (... sentence-3 $\subset$ sentence-2 $\subset$ sentence-1 $\subset$ NP)[5].

[5] The inclusion sign ($\subset$) indicates appending of a series of embedded sentences.

The vowel [a] only is used in three word positions: pretonic, stressed and postonic. In stressed position, 15 [a]s are found before an embedded sentence, 5 of them had important lengthening and 9 showed no important lengthening considering 1.4 as the cutoff point. In the results below "none" stands for cases where neither lengthening nor shortening occurred, i.e. their measurements were not significantly different from the median used as reference, and thus "none" is also the unmarked value..

vowel [a]

	stressed	pretonic (pr2, pr1)	postonic
items	15	28	32
length	5	5	4
short	0	2	7
none	9	21	21

In stressed position one can see that there is a better correlation of lengthening and embedded sentences. In other cases (pretonic and postonic) the results are still unclear.

As for the independent sentences only a couple of cases could be measured because most of the cases had a physical pause at the boundary of independent sentences. Clear cases of prepausal lengthenings are observed at the boundaries of independent sentences if no physical pause is present. The two examples below give a measure of the extent of the lengthening:

142. Caro'lina 'força um re'qu[ɛ26.]br[ω0.0] e conti'nua jin'gando pelo ca'minho. ||

148. [ɩ4.5]s't[a28.5]v[a9.0] e es'tou. ||

Notice that the front, mid, open [ɛ] is used to observe this aspect of sentence level analysis. This is due to the use of only three vowels [(*i, a, ω] which limits the number of cases having independent sentences without physical pauses. Normally all independent sentences will have a physical pause.

Following the tendencies of the model used in this study, data has been gathered at the sentence domain for the phonological phrase found at (1) sentence initial, (2) sentence final and (3) sentence medial position. The results for the vowel [a] show:

stressed [a]: 129 items

1. sentence initial (40 items): 14.75 mm (118 ms) divided by 15.0 mm (120 ms) ==> .98. No change, $K = 1$.
2. before pause (40 items): 19.75 mm (158 ms) / 15.0 ==> 1.32 32 % increase, $K = 2.07$
3. medial position (49 items): 13.0 mm (104 ms) / 15.0 ==> .87 13 % decrease, $K = .57$

The stressed vowel [a] is used because pretonic and postonic positions show results which do not reflect prepausal lengthening in their averages. It seems that on the average (median) the longer the stressed [a] in prepausal position, the shorter the postonic element will be. The pretonic element by the same averaging technique shows no change. The stressed vowel seems to be the one which best reflects prepausal lengthening.

4.4. Semantic factors[6]

The speech of PM contains the same characteristics found in American English in general: emphazis, topicalization, and lexicon novelty. All cases where lengthening was a consequence of semantic factors could be reduced to two rules: one for topicalization and emphasis and one for exclamatory words. Topicalization and emphasis showed negligible differences in their median values and may be included in one group. The speaker does not show predicted patterns that differentiate semantic subclasses except in the two cases set apart here. Tentatively, then, this work attempts to predict emphasis and topicalization by a lengthening factor of $K = 3.0$ (60 % increase) and for exclamatory words, at least in the case of this speaker, $K = 3.7$ (80 % increase).

4.5. Summary of Chapter 4

This chapter contains the results of the four linguistic levels analyzed in the present dissertation. At the phonetic level the acoustic chart of the vowels studied shows that these three vowels in PM's speech are significantly different in their formant patterns (quality) from their American English counterparts, probably as a result of a lax mode of speech of the speaker. Listening to the

6 The term "semantic" is used here in the same manner used in Klatt's (1976) work.

recordings indicates that PM's speech sounds spontaneous to a Brazilian ear and also that it is a very good representative sample of a common variety of BP, the one from the area of Rio de Janeiro. No vowels in BP are distinctive phonemically on the basis of their duration as is found in English. The duration labeled here as "unmarked" is the grand median of each vowel and serves as a reference point in comparing the extent to which lengthening and shortening operate. Postvocalic consonants were found to influence vowel duration in PM's speech, a common phonological process in languages.

At the word level, although further statistical treatment is needed, it was found that the data suggested four different classes of word position: two types of pretonic, one stressed, and one postonic. Only one case of postonic was studied because usage of postonic not immediately after the stressed syllable was rare in the present corpus. Word size was not found clearly significant. However, one has to bear in mind that there are no studies involving factor word size in analysis of BP and that in the present study the analysis of this factor was given limited concentration.

Sentence factors were established according to pauses. Sentence initial position does not show significant duration change. Sentence middle position shows shortening and sentence final position carries a lengthening factor which varies depending on the presence or absence of physical pause.

Finally, the semantic factors, as the term is used in Klatt's (1976) work, showed similar characteristics found in American English: emphasis, topicalization, and lexicon novelty each has a lengthening effect. However, this lengthening does not apply to postonic position.

Chapter 5. Discussion

5.0. Introduction

As Bertil Lyberg (personal communication) remarks, "one thing is to obtain a model that accurately describes the data points, but it is another to find an explanation of why segment duration is lengthened or shortened in certain positions." The present adaptation of Dennis Klatt's (1976) model for American English to BP attempts to make the two following contributions: (1) a comparative discussion (American English and BP) on sound-segment lengthening and shortening, and (2) an accurate description and interpretation of the data points analyzed here. An explanation of these phenomena, in the narrow sense of the word "explanation", is not attempted, but the discussion itself is intended to prepare a path that might lead to an explanation.

The discussion of the whole investigation in this chapter maintains the same format as in the preceding chapters. It starts with an introduction to Klatt's (1976) model with references to Lindblom et al (1981) model. Then each of the four factors analyzed in the speech of PM is discussed.

Following the discussion of the four factors comes the application of the model adapted in this study. In application of the model Klatt's rules for American English are compared to the rules proposed for the present speaker. This reveals not only differences between both languages, but also the limitations of Klatt's model if universal application is attempted.

5.1. D.L. Klatt's (1976) model

Different linguistic factors affect both expansion and reduction as the present analysis attempts to show. In discussing these factors, the reference will come from Klatt's functional block diagram reproduced in Figure 16.

Figure 16: Reproduction of Klatt's block diagram.

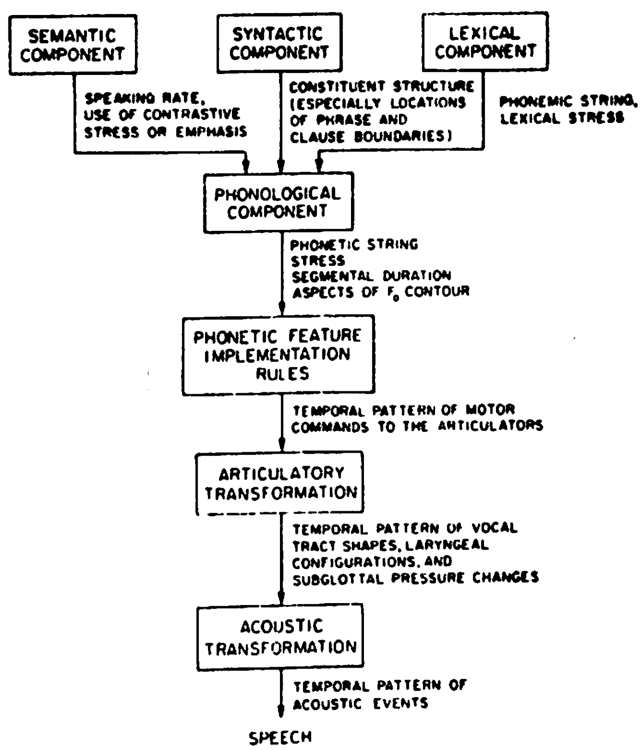


FIG. 2. A functional block diagram is shown of the stages involved in sentence generation. Abstract segmental durations are specified in the output of the phonological component. Physical aspects of segmental timing can be seen in the pattern of motor commands to the articulators, the pattern of articulatory gestures, and the pattern of speech sounds that result.

In the present study the speaker's speech seems to be affected by phonological and word factors in both expansion and reduction. Syntactic and semantic factors operate mostly on lengthening, as will be discussed later. The lexicon does not affect duration through linguistic processing. It is a collection of two classes of words: inherently stressed and inherently unstressed. *These remarks do not necessarily reflect how production processes take place.* These conclusions might be related only to the model chosen here. In other words, the motivation for such a proposal comes from the efficiency of these operations in practical terms only. It is not possible to state here that production also undergoes similar process.

The accuracy of Klatt's model is tested mainly around the linear equation

$$D_o = K \times (D_i - D_{min}) + D_{\min} \qquad \text{(eq 1)}$$

where

D_o, for duration output, is the duration sought at any given point in the text; K is a constant value for each phonological environment, each position in a word, each position in the sentence, and each type of semantic factor (focus, novelty, etc.); D_i is the inherent duration for each sound-segment; $D_{\min}$ is the minimum reduction the inherent sound-segment duration can have: "...stressed vowels possess the property of an absolute minimum duration $D_{\min}$ that is required to execute a satisfactory articulatory gesture (1976, 1215)." The phonology of English does not show such an important reduction (up to complete reduction) in word final position. BP in general does, and the speech of the subject in this study reflects this reduction.

Due to this important vowel reduction observed in word final position before pause and especially before pause at the end of a sentence, an attempt is made to apply equation (1) in this environment as well. It is a basic equation which can be made more complex as Lindblom et al (1981) demonstrated by operating an expansion so that the equation applies specifically to word domain and to phrase domain differently. For example:

$$D_w = D_o \frac{1}{(a_w + 1)^{\alpha_w} (b_w + 1)^{\beta_w}} \qquad \textit{WORD LEVEL}$$

$$D_p = D_w \frac{1}{(a_p + 1)^{\alpha_p} (b_p + 1)^{\beta_p}} \qquad \textit{PHRASE LEVEL}$$

where

D_o = the inherent segment duration

D_w = the segment duration at the word level

a_w = the number of syllables that follow at a given point

b_w = the number of syllables that precede at a given point

$\left.\begin{matrix}\alpha_w \\ \beta_w\end{matrix}\right\}$ = constants

D_p = the segment duration at the phrase level

a_p = the number of main stresses that follow at a given point

b_p = the number of main stresses that precede at a given point

$\left.\begin{matrix}\alpha_p \\ \beta_p\end{matrix}\right\}$ = constants

The objective of the present research does not reach that far because

Klatt's model seems to be as effective for the present purposes without additional complexities.

Klatt seems[7] to have assigned an average value for *K*, after noting only negligible differences for the values of *K* as a function of each individual sound. For example, *K* is a function of the position, but in fact these values are related to both position and to each type of sound. The differences observed for each sound must have had little importance. The speaker analyzed here also confirms this. It is possible to work by assigning a global value for all sound-segments (here, [ι, a, ω]) according to position only. In evaluating the effectiveness of this model, vowel estimated values will be considered acceptable if they fall within the interval established from observations of that vowel distribution. This interval is established according to [-2 to +2] standard deviations of a normalized distribution of the given vowel, or according to the quartiles of the original distribution as discussed in Chapter 3. The interval is relative to the inherent segment duration. These points are at this point arbitrary because they could not be obtained by perceptual tests. They are the same percentage points used in Klatt' work. In Klatt's (1976) work the interest lies on the 1.4 point because of his model. The present model also considers the left side of curve, and thus correspondingly the point 0.7 is observed.

[7] I have no means for being assertive about this point for I have no evidence on how Klatt worked at this point.

K is the first element to be given a value in this process. K changes according to the linguistic domain it applies and then to the point it applies in each linguistic domain. The value of K is established by operating on the original equation (1) making

$$K = \frac{D_o - D_{\min}}{D_i - D_{\min}} \qquad \text{(eq 2)}$$

D_o is obtained by the median value of each of the three sound-segments in a given position. As observed above, K should have been established as a function of both position and of each sound-segment, i.e. $K\ (p,s)$. Since the possibility of simplifying the equation does exist, the present work also considers K as a function of position only, $K(p)$.

Let's suppose that in one of the pilot studies, the following results were found for stressed [a] in sentence final position:

D_o ([a] in sentence final position)	=	19.0 mm (152 ms), lengthening
$D_{\min}$	=	5.6 mm (44.8 ms)
D_i	=	8.0 mm (48 ms)

By substituting these values in the equation above,

$$K = \frac{19.0 - 5.6}{8.0 - 5.6} = 5.58$$

Thus the vowel [a] is increased by a factor of 5.58 (almost 140 % increase), when found in stressed position at the end of a sentence in the pilot study above. Then the same operations apply for [ɩ] and [ω] as well as to each of the positions. If *K* has a value greater or equal to 0.0 and smaller than 1.0 a shortening process operates; if *K* is greater than 1.0 then, a lengthening rule operates, as in the example just above. Of course, if *K* is equal to 1, then there can be no change, since the result will always be equal to the established inherent value. By the same token, a complete reduction will occur only if *K* is set to 0.0.

5.2. Phonological and phonetic factors

5.2.1. The formant structure of [ɩ, a, ω] *relative to their duration*

In terms of formant structure, the phonetic quality of the three vowels under analysis here when compared to their American English best vowels uncovers the following characteristics in relation to duration. As discussed in chapter 2 (p. 28) articulatory displacement causes longer or shorter durations according to the distance of the displacement. The frequency of the two first formants indicate jaw opening and length of front vocal tract, and vocal tract opening and length relate to duration. More precisely, frequency of F1 is primarily dependent on the degree of openess and frequency of F2 is primarily dependent on the length of the front vocal tract (Fant, 1970). A few consequences of such a theory is that, in relative terms, the more open the vowel, the higher the F1, the more fronted the vowel, the higher the F2, the more rounded the vowel, the lower the F2 and so forth.

The three vowels [ɩ, a, ω] in the speech of PM are compared below to American English closest counterparts following the theory exposed in the former paragraph. For example, PM's [ɩ] has its two first formants in the 314 Hz and 1812 Hz area; in American English its closest counterpart is, in articulatory terms, the front, high, lax [ɩ] with its two first formants in the 400 Hz and 1920 according to Ladefoged (1975, 170) as shown in Figure 15, page 69. One should bear in mind that Ladefoged's numbers are obtained from vowels in carrier sentences. There may be some differences in these numbers if obtained from continuous speech. In the absence of formant values from continuous speech in English, the ones from carrier sentences have to be used at least for a first approximation. The F2 of American English [ɩ] indicates that this vowel is more fronted than [ɩ] in PM's speech. The F1 of American English [ɩ] is also higher indicating an American English vowel more open than PM's vowel. In other words, there seems to be a greater articulatory effort in American English [ɩ] that should reflect a longer duration. Similarly the two other vowels have no counterparts in American English. They combine formant values from two vowels each as shown below. Chapter 4 (p. 69) contains formant frequency values for reference.

AE	BP	comparisons with prediction for durations
[i]	[ι]	AE slightly less open, more fronted. AE has longer duration due to a different factor, namely tenseness.
[ι]	[ι]	AE more open, more fronted. AE has longer duration.
[ae]	[a]	AE more open, more fronted. Longer duration.
[*a*]	[a]	AE more open, more backed. About same duration.
[ω]	[ω]	AE more open, more backed. Longer duration.
[u]	[ω]	AE about same opening, more backed. Longer duration.

5.2.2. *Unmarked (inherent) vowel duration*

The unmarked values for this speaker's vowels are given in Chapter 4, page 69. These vowel values will usually increase in strong position or reduce in weak position. However, correlation of stress and duration (Jakobson and al (1952), Lehiste (1970) and so forth, for American English, and Head (1964) and Major (1985), for BP, was indeed observed in the case of PM's speech, but a significant number of exceptions found. Limiting the observations to the three vowels under analysis here, a list of words below shows that in connected speech stressed vowels can be shorter than unstressed ones in comparable environments. This suggests that a more extensive look at this problem might reveal more examples. What can be *expected* is that each of these vowels might multiply its inherent duration by a factor of $\cong 2.0$ when in stressed position. Duration alone is not phonemically distinctive in BP.

Table 4: Some examples or words in connected speech showing that stressed vowels can be shorter than unstressed vowels in comparable environments. The numbers in the leftmost column indicate the corresponding line in the text.

sent. #	word	measurement in mm	change
22.	bicha'rada	b[ι3.5]ch[a10.]'r[a7.]d[a7.5]	30 %
113.	'lata	'l[a8.5]t[a10.]	15 %
139.	pa'ssar	'p[a10.5]ss[a8.5]	20 %
180.	diri'gido	d[ι11.]r[ι7.5]g[ι6.5]d[ω0.0]	60 %
200.	'cada	'c[a10.5]d[a11.5]	8.5 %
	esconde'rijo	[ι2.]scond[ι15.]'r[ι16.5]j[ω1.5]	-9 %
233.	in'siste	in's[ι8.]st[ι8.5]	6 %

These values do not contradict the average results already seen where stressed vowels are twice as long as unstressed vowels. Such results mean that stressed vowels are longer than unstressed vowels *on the average*. These examples reflect an important phenomenon and also indicate that an unstressed vowel when longer than the stressed one will be 8 to 36 msec (15-60%) longer.

Almost all information we have in phonetic theory is the result of studies using carrier sentences or isolated segment(s). Results from connected speech are from recent dates. Klatt's work is pioneering in this aspect. Different linguistic components are operating in connected speech. Detailed information about the durational patterns of American English can be found in many works, especially in Peterson and Lehiste (1960, 702). Unfortunately, Peterson and Lehiste's work does not employ connected speech. It is, then, comparable to the present study only qualitatively in the sense that "a given sound-segment *x* is longer or shorter than the sound segment *y* ..." More readily comparable are Klatt's (1975, 1976) global measurements, i.e. all vowels, for American

English:

	stressed vowels	unstressed vowels (schwa included)
	130 msec	70 msec

The same type of approach in the present study using three vowels shows:

[ɩ,a,ω]	120 msec	52 msec

This speaker of BP therefore shows global measurements of the three vowels to be shorter than American English vowels in both stressed and unstressed positions. Considering only the three vowels in this study, these global measurements are similar in both languages, but the *stressed:unstressed* ratio is *greater* in the BP speaker's speech. The ratio seen here (> 2 : 1) may indicate, for example, that this speaker of BP has predominantly a stress-timed rhythm. In other words, there is a stress-timed rhythm characterizing PM's speech, but it alternates with other rhythm patterns. For instance, syllable-timed patterns are found and melodic stress involves larger units than the ones found in the stress-timed patterns.

5.2.3. *Effects of postvocalic consonant*

Results from studies dealing with isolated word or sound-segments show that a vowel tends to reduce before unvoiced consonant and expand before voiced consonant (Delattre, 1966; House and Fairbanks, 1953; Peterson and Lehiste, 1960). Klatt remarks that these reductions or expansions seem to be more important in English than in other languages recorded. This is especially true in the case of English, when the fricatives /s/ or /z/ follow the vowel.

In connected discourse this is confirmed by Klatt's work, although one might expect this difference to be minimized because of the various operating factors. In the phonotactics of BP only three underlying consonants appear in final position: /S, l, r/ (Mattoso, 1970, 48).[8] The syllable final /l/, however, always undergoes vocalization and it becomes [ω], and in the case of PM syllable final /S/ and /r/ become [š] and [x] respectively when the following consonant in the following syllable is voiceless and become [ž] and [ɓ] respectively if voiced. Of these surface representations the [š] and [x] have sufficient frequency of occurrence in the present study for reliable results. Vowels in any position in this study are clearly reduced when followed by [š] and [x]. The consonant /r/ (fortis /r/) in PM's speech is realized as a velar [x] or an approximant [ɓ] according to the phonological rule already discussed in chapter 4. Often, however, they alternate in free variation depending on the extent of the influence exerted by the environment. In the case of English, research has been done using minimal pairs for a better comparison, but in BP consonants do not contrast phonemically in postvocalic position. House and Fairbanks (1953) observed that postvocalic consonants in phrase final position lengthen the preceding vowel by 50-100 msec. This difference is smaller in non-phrase final syllables: about 10-20 msec. Thus in the case of BP the extent of the true effect /S/ has upon the preceding vowel must be inferred in a different manner.

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[8] More precisely, Mattoso suggests a fourth consonant: an archiphoneme of nasality /N/ after all nasal vowels.

As discussed in the section on syntactic effects in this study, there are uncertainties in this speaker's reading regarding more subtle boundaries such as phrase domain boundaries. For this reason, this study cannot yet consider the effects of /S/ at these syntactic points. Therefore, the median duration of a given vowel within a word is the point of reference. The /i/ vowel reduces most significantly and for this reason is used as an example.

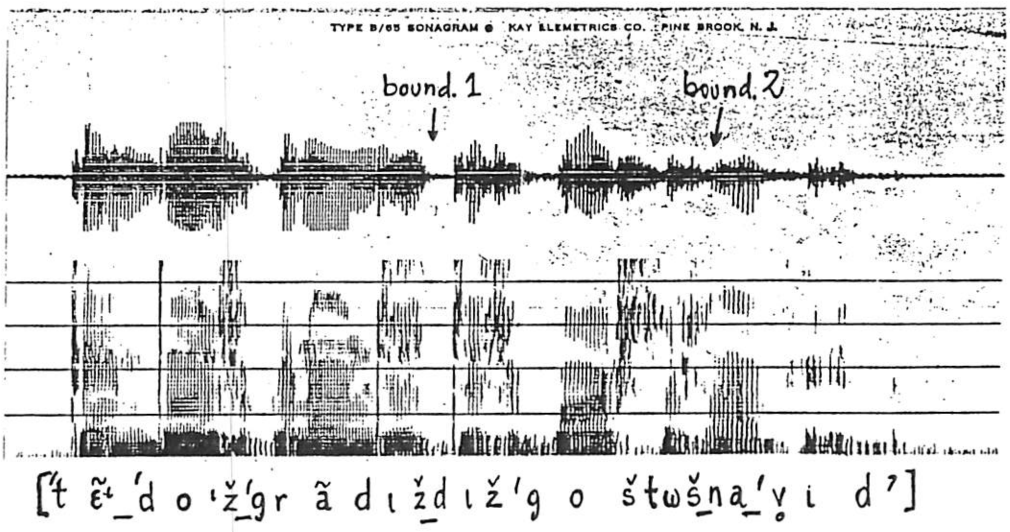
In pretonic position it can be expected in this study a median duration of c. 44 msec in pr2 position and c. 52 msec in pr1. One might think of a mean of 48 msec to refer to both pretonic positions. In both pretonic positions, the vowel /i/ has a range of c. 30-50 msec reduction (40-100%), i.e. up to complete reduction. More precisely, an /i/ followed by [š] in pr2 position ("esqui'sita," "espar'tilho," etc.) has some 40-100% reduction; an /i/ followed by [š] in pr1 position ("deses'pero, "ex'plode," etc.) is less affected: 30-40 msec (40-80%) reduction, i.e. without complete reduction observed.

In postonic position the expected median duration of /i/ is c. 48 msec for this speaker. The range of reduction for /i/ in postonic is of c. 30-40 msec, i.e. similar to pr1 above, having no complete reduction.

The text does not have an important occurrence of phonetic [ž] in syllable final position within a word except in one instance, in the word "des'gostos" (line 4.). In an attempt to make a meaningful comparison of these segments, the phonetic [ž] has been included across word boundaries ("... a'penas 'dona Co'ruja ..." etc.). Analysis of these cases show that when the /S/ becomes [ž] the preceding vowel does not show reduction. At times there is no voicing and an important reduction is observed. These are cases such as the one below in Figure 17 where "... 'grandes des'gostos na vida ..." shows in the first word boundary a phonetic [ž] following a non reduced [ɩ], whereas the second word boundary has a phonetic [š] following a reduced [ω]. Analysis of these instances suggest that no durational change needs to be assigned in case a [ž] follows the vowel; in case the [š] follows the vowel, the inherent duration of the vowel should be reduced at the phonetic domain, by a factor of 0.5.[9]

[9] A better explanation of reductive process seems to be given by Câmara, (1977) (see following section 5.3). In the future I intend to spouse that explanation. Postvocalic influence of voiceless consonant seems to be not as strong in PM's speech as originally thought.

Figure 17: Superimposed spectrograms showing the string "tem dois grandes desgostos na vida" where at the word boundaries of "grandes **(bound. 1)** desgostos **(bound. 2)** na" we can observe that the underlying /S/ is realized as voiced [ž] and as voiceless [š]. No durational change is observed in the first case, but durational change occurs in the second case.



5.3 Word factors

At the word domain, some insightful observations have been made by Major (1985), formalizing and suggesting an explanation of what had been explained impressionistically by Câmara (1949, 1977). Major's formalization is that any phonological processing will take place first in postonic position, then in pretonic and lastly on stressed position. Thus he stays within the limits of three positions. Câmara (1977, 47-48), although working impresssionistically, describes the phenomenon more convincingly. Mattoso differentiates between two kinds of pretonic: (1) pretonic starting with a consonant (stronger), and (2) pretonic starting with a vowel (1977, 47). The consequence is that, as we can confirm in the speaker of the present study, there are three degrees of *atonicity* in the case of paroxitone words:

(1) maximum atonicity -- postonic

(2) median atonicity -- pretonic non initial or initial with vowel

(3) minimum atonicity -- pretonic initial beginning with consonant

The speaker of the present study does not limit this pattern of tonicity paroxitones. He maintains this pattern as the stress moves rightward (oxitone) or leftward (proparoxitone). Thus, this Brazilian speaker's recording confirms Mattoso's description that it is possible to subclass pretonic in two groups, and then to subdivide the words into four positions from weakest to strongest:

post1 > pr1 > pr2 (word initial beginning with consonant) > stressed

The position pr2 (two syllables before the stressed syllable), is in a significantly stronger position than pr1 (immediately before stressed syllable). After observing this empirically in the whole corpus it was possible to see that pr2 is especially strong in word initial. Almost invariably this speaker gives a rising contour on pr2, especially if the word starts a syntactic unit. At word domain BP does reflect the difference between both pretonic positions pr2 and pr1. Examples are not difficult to find in words such as "mo'rango," "cor-de-'rosa," "me'nino" where the "o" and "e" preceding the stress marks will become either [o] or [ω], and [e] or [ι]. The subject in this study shows even an intraspeaker variation by alternating [o] and [ω] for the orthographic "o" in "Caro'lina."

The behavior of the distribution function of these groups (pr2, pr1, stressed and post1) has each one of them as normally distributed. Then, analysis of variance illustrates that these groups have a highly significant inter-group relation which can be interpreted as groups of different natures. It is still early to further attempt refining, but this corpus does show this hierarchy of phonological processing. Depending on the scope of each study, I believe we can keep subdividing these classes further.

The results below come from the whole noun phrase and not from the isolated lexically stressed word. Under such conditions there is an important number of function words which fall under pr2 label, making the median value of pr2 smaller than pr1. Pr2 in noun phrases such "a mi'nhoca" ("the worm"), is a pr2 held by a function word. In such cases pr2 is shorter than "a"s inside the head noun like "Caro'lina," "natu'reza," ("nature") etc. The present model gives different weights to positions pr2 and pr1. This is due to differences observed in the median duration of vowels in these positions when pr2 has a consonant in the syllabic onset. The difference is numerically clear when the medians of both pr2 and pr1 are taken considering the case of pr2 with a consonant in its syllabic onset.

Thus, at the word domain one can assign four constant values to increase or decrease these vowels' inherent durations. These constants are obtained in the same manner already mentioned, *viz.* by applying equation (2). The constants accurately predict an output for duration at the word domain if used in the linear equation (1).

5.4. Sentence level factors

In terms of practical application at least, the text studied shows that the syntactic component operates mostly on lengthening. Shortenings of sound-segments in sentence final position is a process which can perhaps be controlled by word domain and phonological components. Lengthening at syntactic level indicates syntactic units. At the syntactic level there is a shortening rule to account for medial position at the sentence level. It looks suspicious then, to say that shortening is controlled also by sentence level factors. The motivation for this suggestion comes from observations of stressed vowels in sentence final position and from the average (median) increase. Strong positions within a word (stressed) seem to offer the best data for analysis in sentence final position. Weak positions are more easily influenced by other linguistic components: position in the word, size of word, sound following a given sound observed, etc. Strong positions are the least affected, but even so they reduce as well.

Following Klatt (1975) it was determined which segments were greater than 1.4 times the median duration of the segment studied. Values that fall after this cutoff point are segments indicative of statistically significant changes, which in this case are the syntactic boundaries. This is used to establish significant lengthening. For significant shortening the cutoff point is 0.6 times the median. Only stressed vowels at the end of a sentence are used.

These three vowels show an average (median) increase of 24 msec (20% increase) in sentence final position. Measurements of stressed [a] before all pauses, not only the ones in sentence final position, demonstrate a more important lengthening of 38.4 msec (32% increase). Klatt (1976, 1211) mentions past studies (Oller, 1973; Klatt, 1975) which find that a syllable before a pause increases by c. 60-200 msec. This seems to be an increase at least twice as long as this speaker of BP. Klatt (1975) averaged this increase in duration at all phrase boundaries to be 30%. This last remark is discussed in detail in the paragraph below.

From Klatt (1976, 1211) one reads "prepausal lengthening also seems to occur at phrase and clause boundaries when there is no physical pause present in the acoustic signal." Using the three vowels studied, four points at the sentence domain are considered in an attempt to confirm this idea. Again, a factor of 1.4 is used as cutoff point. Klatt (1975) explored syntactic points such as the boundary between a noun phrase and a verb phrase, the end of a sentence, before a conjunction, between a noun and a dangling prepositional phrase, between a noun and a modifying prepositional phrase, and before an embedded clause. The present analysis looks at the following syntactic points: the sound segments inside a word before embedded sentences, before independent sentences, before non-restricted clauses, and at phrases heading complex embeddings (... sentence-3 $\subset$ sentence-2 $\subset$ sentence-1 $\subset$ NP).

5.4.1. *Embedded sentences.* The vowel [a] is the sound-segment used as a reference. Thus, through the vowel [a] three word positions are observed: pretonic, stressed and postonic. In stressed position, 15 [a]s are found before an embedded sentence; 7 of them had statistically significant lengthening, 7 showed no significant lengthening, and one exhibited significant shortening using 0.85 and 1.2 as the cutoff points.

Embedded sentences have not shown significant durational changes in all embeddings. This may be explained by the methodology used here. The reader needs a minimum planning of the syntactic units because he has the written text in front of him. As one may foresee, prepausal lengthening and lengthening of vowels preceding an embedded sentence have a more predictable occurrence in a retelling of the story or in any other situation where a no written form is presented to the speaker. This finding has not been mentioned in the literature and is a conclusion from this study.

A second reason why the signalling of syntactic boundaries is not present as often as Klatt predicted is that the text used in this analysis is closer to the syntax of texts told orally than to a well written form of BP. Thus the syntax is not a refined one. Finally, an attempt to consider only boundaries containing a conjunction shows an improvement on shortening, instead.

Klatt (1975, 135) provides a table comparable to the results in Chapter 4. The table from Klatt's work is reproduced below in Table 5. In Klatt's paper (1975) a word is observed to lengthen or shorten according to its position in the sentence. If this is the case in English, the speaker of this study does not share the same characteristic. It is still too early to attempt a precise description of what is happening in the speech analyzed here, but it seems that the word keeps a certain duration within a given interval. The only comparable case in this text comes from the word "Carolina," the main character of the story. The name "Carolina" appears 17 times in the text in different points of the sentence, included points before embedded clauses. The median duration of the whole word "Caro'lina" is 68 mm (544 msec). If 0.7 and 1.4 times the median are the cutoff points for judging significant durations, there is no occurrence of the whole string "Caro'lina" that is shorter or longer than those points. In case we use 0.85 and 1.2 there is only one case where the whole word duration is 93 mm (744 msec). This happens in sentence number 226: "Sou Caro'lina, não es'tão 'vendo?" "Caro'lina" is on focus after the copula "sou." The pause which does not occur where the comma is located. The only cue to that boundary and to the importance of that focus is in the first "a" of "Caro'lina" which increases significantly to 14.5 mm (116 msec).

Table 5: Klatt's (1975) table III is reproduced. "Summary of the sentence locations of segments with durations greater than 1.4 times the median (column A) and greater than 1.2 times the median (column B) for that segment type and stress level. The fraction in parentheses indicates the number of times that the duration threshold was exceeded divided by the total number of examples of that boundary type in the corpus."

Sentence location	A	B
(1) At the boundary between a noun phrase and a verb phrase	(8/13)	(11/13)
(2) At the end of a sentence	(6/13)	(9/13)
(3) Before a conjunction	(6/11)	(9/11)
(4) Between a noun and a dangling pp	(2/3)	(2/3)
(5) Between a noun and a modifying pp	(6/17)	(7/17)
(6) Before an embedded clause	(0/6)	(4/6)
(7) Does not fit into above categories	0	19
Totals	28	61

5.4.2. *Independent sentences.* In the case of independent sentences only a couple of cases could be measured because most of the cases had a physical pause at the boundary of independent sentences. Clear cases of prepausal lengthenings are observed at the boundaries of independent sentences if no physical pause is present. The two examples below give a measure of the extent of the lengthening:

142. Caro'lina 'forҫa um re'qu[ɛ26.]br[ɷ0.0] e conti'nua jin'gando pelo ca'minho. ||

148. [ɩ4.5]s't[a28.5]v[a9.0] e es'tou. ||

Because of the difficulty in finding independent sentences without physical pauses, cases involving different vowels from the ones analyzed here are also considered. Therefore the first example above contains a different vowel, the mid, front, and open [ɛ]. The number of cases is limited, but the ones found confirm the importance of prepausal lengthening in announcing a syntactic boundary when the physical pause does not perform this function.

5.4.3. *Non-restricted phrases.* Considering the cutoff points 0.85 and 1.2 these points are always clearly signaled by one of the vowels showing important increase of the vowel duration, if a physical pause does not appear. Below are some examples:

3. C[a15.5]ro'lina, a mi'nhoca ...
8. [a11.5] mi'nhoca, coi'tada ...
41. C[a19.0]r[ω16.5]'lina, amuada, ...
91. C[a15.0]ro'lina, ...
143. Don[a7.5] C[ω15.5]'r[ω19.0]j[a0.0], ...

5.4.4. *Complex embeddings.* To my knowledge no study on duration has studied the point where complex embedded sentences is signaled by the duration of its heading. The most interesting case in the text studied here has at its heading a complex syllable nucleus. Although these complex nuclei are not studied here, this case has been measured for the interest it contains. Thus sentence number 54, the second portion of the complex nucleus in "dia" has a very significant lengthening of 9.5. As the second portion of a complex syllable nucleus, one expects it with a very short duration of c. 3mm.

There are other cases of interest such as:

9. ... é um bi'chinho d[a13.] 't[ɛ24.]rr[a7.] que não tem ...

69. n[ω9.5] L[a9.]'g[a19.]rt[ω2.] ...

194. ... é que [ε19.]la completamente ...

203. [a10.5] mi'nh[ɔ 22.]c[a5.5], ...

Examples are easier to find in cases with noun phrases as headings of these relative clauses. In similar situations, when a listing of facts is to be given, before the point where the listing starts, the boundary is signaled by an increase in the vowel duration. Sentence number 26 contains an example:

26. [ι8.] p[ω11.5]r s[ι4.5] sent[ι19.5]r | (very short) tão insatisfeita ...

In this particular case, the main sentence is held at the end of the whole sentence as in a topicalized position. However, before this main sentence is realized the listing of facts is signaled by "sentir" in the example above.

In conclusion to the preceding discussion on the syntactic domain, data has been gathered at the sentence domain *according to the phonological phrase*. In other words, using the phonological phrase as the unit three areas are established: (1) sentence initial, (2) sentence final and, excluding (1) and (2), (3) sentence medial position.

The stressed vowel [a] is used because pretonic and postonic positions show results which do not reflect prepausal lengthening in their averages. It seems that on the average (median) the longer the stressed [a] in prepausal position, the shorter the postonic element will be. Using the same averaging technique, shows no change. The stressed vowel seems to be the one which best reflects prepausal lengthening. These factors are then used in the application of the model at the *sentence domain*.

5.5. Semantic factors

This speaker demonstrates the same semantic factors influencing his speech as we see in English: topicalization (focus), lexicon novelty, prepausal lengthening in the semantic sense of controlling the last word of a linguistic unit in anticipation for the next syntactic unit, and exclamatory words. These influences are more difficult to measure. An interjection, for example, varies greatly with little possibility of predicting the extent of these variations. It is necessary, then, to work on an idealized situation for some cases. There are cases more bound to a certain predictability, such as topicalization and prepausal lengthening, because these are more linked to the syntactic structures. From the text used it is felt that a more reliable attempt to predict the lengthenings of these vowels are cases of focus, i.e. emphasis on a word without need to change its word order; topicalization, i.e. emphasis through rearranging the word order or the clauses or sentence order. Lastly, an attempt is made to predict the durations of interjections. Perhaps the data is insufficient, but focus and topicalization did not show an important lengthening between them, although they carry significant lengthening. Both were given the same lengthening factor.

Due to the methodology used here, lexicon novelty has not been given a lengthening factor. The speaker was well familiarized with the text before reading it.

5.6. The Application of the model

The present work is based on results and analysis done exclusively at the acoustic domain. Klatt's work provides a list of durational effects that convey linguistic information from the speaker to the listener, instead of producing a descriptive model capable of predicting the durations of individual segments in English (1976, 1208). Klatt does, however, set forth an outline for the realization of a descriptive model (1976, 1216). Klatt's conclusion is that in English "duration often serves as a primary perceptual cue in the distinctions between (1) inherently long versus short vowels, (2) voiced versus voiceless fricatives, (3) phrase-final versus non-final syllables, (4) voiced versus voiceless postvocalic consonants, as indicated by changes to the duration of the preceding vowel in phrase-final positions, (5) stressed versus unstressed or reduced vowels, and (6) the presence or the absence of emphasis." (1976, 1208) Finally, Klatt suggests rules to reduce or expand sound-segments in English that apply recurrently from local to outer units according to the formula:

$$D_o = K \times (D_i - D_{min}) + D_{min} \qquad \text{(eq 1)}$$

To list, as Klatt did, the durational effects that convey linguistic information in BP requires perceptual tests. It is not yet possible to make perceptual tests. How does one assess, then, the importance of the linguistic information cued by duration if only the acoustic domain is studied? The important linguistic information may be filtered out at first by means of statistical analysis of the data obtained acoustically. Then, in a later stage, not in this dissertation, perceptual tests will be attempted to confirm the results obtained statistically.

Klatt (1973b) already had preliminary attempts to apply a percent change model which applies several rules at once (i.e. not cyclically), which demonstrated that this model failed. Lindblom and Rapp (1973, 47) did propose a model for Swedish with recurrent rules going from outer units (sentences) cyclically into inner units (clauses and words). Recently, Lindblom and al (1981) moved to Klatt's approach going from inner to outer units. There are many more details in the Lindblom and al (1981) model which make it quite attractive to test for other languages as well. Because of the simplicity and effectiveness of Klatt's model, which uses only four rules and nine parameters to predict average vowel durations occurring in 56 situations (Klatt, 1976, 1217), the present study tested this model first.

It would be very difficult to apply rules operating at the sentence domain first, then into inner units, in the case of this speaker of BP. Considering the cases of complete reduction for unstressed vowels, a rule applying cyclically cannot apply again in the inner units if needed. In a sentence like "Isso é um assunto muito quente", if a reductive rule applied first at the end of the sentence reducing the last vowel of "quente" to 0.0, namely a complete reduction, then rules involving application at clauses, word and syllable domains would have been obliterated, since no more reduction could operate. In other words, it would have been equivalent to say that factors such as clause, word and syllable domains did not exist. In my opinion a model to include these factors would have to go from local to outer units. My linguistic experience shows that there is no complete reduction either at the word domain or at the syllable domain, when these domains are taken by themselves. This is true in the sense that a word spoken in isolation shows no complete reduction. Complete deletions occur because the context allows for them. Without context (isolated units) sounds need most of their set of features, if not all, to convey their meanings. A rule operating in the inner units, namely syllable domain, will show some deletion, but not complete deletion. It only becomes completely deleted when it reaches outer units.

The main units in an oral narrative have to be obtained according to the physical pauses. The physical reality of a speech, readily available information, is used to form the basis for the prediction of sound-segment duration in all levels, in a first approach. The *stressed vowel* [a] is used for information at all domains of speech analyzed. The [a] has a high frequency of occurrence, is a stable vowel, and among the three vowels studied, the one which presents the minimum possibility to be affect by possible idiosyncrasies this model might present. This model divides the phonological phrase into three main parts: beginning, middle and final.

Phonological phrase

[pause] ___1____ ......2...... ____3____ [pause]

Each of these three areas above (1, 2, 3) are further subdivided into lexically stressed and unstressed vowels. Sentence initial area (1) and sentence final area (3) of the phonological phrase can have only one lexically stressed syllable; sentence medial area can have any number of lexically stressed syllables (0-∞).

Analysis of the present text using this framework shows that area (1), sentence initial, has neither decrease nor increase of the inherent segment value. Medial sentence area shows a decrease by a factor of lengthening, has an increase by a factor of 1.32. Application of the rules established here progresses from local to outer domains, but seems to need to set the process at this domain first (phonological phrase) before the rules apply cyclically from local to outer domains.

Klatt's rules for English (1976) and the rules of the present study for BP can be compared and the comparison open excellent perspectives in this analysis. Klatt's rules for *for vowels* are intended to predict "vowel durations in strings of nonsense syllables spoken as a word in a carrier phrase" (1976, 1217). Below the those rules for vowels from Klatt (1976) are reproduced for comparison.

Table 6: Rules for vowels as they were proposed in Klatt's work are reproduced below.

Rules for predicting vowel durations in strings of nonsense syllables spoken as a word in a carrier phrase.

Inherent phonological durations D_i are derived from phrase final monosyllables ending in a voiced stop, e.g., "bag" or "big."

Phone	D_i	D_{min}	Ratio
/ae/	240	105	0.42
/ɪ/	160	65	0.42

Rule 1. If the postvocalic stop is voiceless, reduce the vowel duration by 45 msec.

$$D = D - 45.$$

Rule 2. Shorten an non-phrase-final vowel by about 35%, that is, set $K = 0.6$ in the equation below because D_{min} is about half of the inherent vowel duration

$$D_o = K \times (D - D_{min}) + D_{min}$$

Rule 3. Shorten an unstressed vowel by $K = 0.4$, except that a word-initial unstressed vowel of a polysyllabic word is only shortened by $K = 0.55$

$$D_o = K \times (D - D_{min}) + D_{min}$$

Rule 4. Short all syllables in a polysyllabic word by 15%, that is, set $K = 0.78$.

$$D_o = K \times (D - D_{min}) + D_{min}$$

5.6.1. Rules for the speaker of Brazilian Portuguese

The rules of the present study are listed below. They were established for the prediction of shortening and lengthening of the three vowels [ɪ, a, ω]. They have to be applied according to equation (1) $D_o = K \times (D - D_{min}) + D_{min}$. Equation (1) operates cyclically from domain 1 up to domain 4. The values for K are obtained by means of equation (2) $K = \frac{D_o - D_{min}}{D_i - D_{min}}$. The inherent duration of each vowel initializes each process in any position within a word. The subsequent D_i values are the outputs of the application of the rule just applied.

Level 1. Sound segment domain:

Rule 1: INITIALIZATION. From the inventory the inherent sound segment duration is set. D_i of PM's vowels [ι, a, ω]:

[ι] = 56 ms (7.0 mm) [a] = 64 ms (8.0 mm)

[ω] = 48 ms (6.0 mm)

Rule 2: If the phonetic voiceless fricative [š] follow the vowel within the same syllable, shorten the vowel by K = -1.17 (65 % decrease). In case the consonant is [x], shorten the vowel by 25%, i.e. K = .17

Rule 3: If a phonetic voiced consonant follows the vowel within the same syllable, no change, K = 1.

Level 2. Word domain:

Rule 4: If the vowel is in postonic (post1) position, decrease the vowel by 25%, i.e. K = .17

Rule 5: If the vowel is in pretonic (pr2) position, not preceded by a consonant, decrease it by 10 %, i.e. K = .67;

if the vowel is preceded by a consonant, increase it by 42 %, i.e. $K = 2.4$

Rule 6: If the vowel is in immediate pretonic (pr1) position, increase it by 13 %, i.e. $K = 1.43$

Rule 7: If the vowel is in stressed position, increase the vowel by 90 %, i.e. $K = 4$.

Level 3. Sentence domain:

Rule 8: If the vowel is at the beginning of a sentence or a pause, no change, $K = 1$.

Rule 9: If the vowel is in sentence medial position, decrease by 13 %, $K = .57$

Rule 10: If the vowel is in sentence final position without physical pause, increase the vowel by 20 %, $K = 1.67$ if the vowel is in a major final position, and a physical pause follows, increase the vowel by 32 %, $K = 2.07$ (*Rule 10 does not apply to vowel in post1*)

Level 4. Semantic domain:

Rule 11: If vowel is within a focused word, increase the vowel by 60 %, $K = 3$.

Rule 12: If the vowel is in an exclamatory word, increase the vowel by 80 %, i.e. $K = 3.7$

(*Rules 11 and 12 do not apply to vowel in post1*)

These are the rules for the four domains studied. Adding different domains, i.e. factors, increases the number of rules creating a better predictability and a better information of descriptive nature. However, in terms of economy, the more rules we create the less efficient the system becomes.

5.6.2. Comparing Klatt's (1976) rule with the present ones

Observing both Klatt's (1976) rules and the present rules for one speaker of BP reveals the following. First, future perceptual tests will indicate which of the present rules at the acoustic level are redundant at the perceptual level. For instance, rules 3 and 8 in the present set of rules can be predicted to be redundant because these rules cause no durational change. Although it is best to carry out perceptual tests the interest has to be on duration changes equal to or greater than a just-noticeable difference (JND), which seems universally to be a 20% change (see Klatt, 1976, 1218-19). Rules 3 and 8 will be left aside when significant durational effects take place. The other rules, however, require perceptual tests for deciding whether they are redundant.

When comparing both sets of rules one has to bear in mind that all rules in Klatt's model *shorten* vowels. Such unidirectional effect is due to the method for deriving inherent vowel duration in the model for American English. In that model the inherent vowel duration is the *longest* vowel (1976, 1217) and from a longest vowel duration only reductions can operate. The present model is bidirectional because the phonological operations can either shorten or lengthen the vowel segments relative to a median point. The advantage of developing such a model is that it may help explain both shortening and lengthening without relying on former results, since former results are not always available. Extensive research shows that the longest duration in English happens in phrase-final monosyllables ending in a voiced stop.

Thus, rule 1 in Klatt has a fixed shortening of -45 msec relative to the inherent longest vowel duration. The phonotactics of BP does not allow for words ending in a voice stop as English does. The solution in the present investigation is to derive inherent vowel duration from the median duration of each vowel. The present study attempts to explore all the possibilities of the data both through statistics and equation (1). Rule 1 (initialization) result from the grand median of each vowel, and rule 2 from giving *K* a fixed value for each situation, after transforming equation (1) in equation (2).

If one is cautious rule 1 in Klatt can be compared with the present rules 1, 2, 3 at the phonological domain. Rules 2, 3 were derived from a limited set because there is a low frequency of occurrence of consonants following a syllabic nucleus. Besides, the word initial sequence [ɩ] + [fricative] predominates. Perceptual tests, again, will in a future work indicate if it is necessary to split this rule 2 into two rules: one for cases of [ɩ] + [voiceless fricatives], and another for liquids.

In sum, the different phonotactics of American English and BP do not allow for a direct comparison. At best, it can be said that in Klatt's work there is a fixed decrease of -45 msec (c. 19 to 28%) relative to the longest vowel. The shortest American English vowel [ɩ] (160 msec) has a 28% decrease, and the longest American English vowel [ae] (240 msec) has a 19% decrease when both are followed by a voiceless stop. The present study has an equivalent phonological process in rule 2, but it involves only voiceless fricatives. After rule 1 initializes an inherent value for a given vowel, rule 2 uses equation (1) to decrease the vowel by 65 % and 24 % (K = -1.17 and .17).

Rule 2 for American English reflects both phrasal effects and word effects because Klatt assumes that word level effects are "negligible compared to phrase position influences" (1976, 1216). Such a view fits the present rules at the word domain because the word is studied within a phrase. For American English, then, equation (1) starts to apply in rule 2 by setting K = .6 (35% decrease) for non-phrase final vowels. This reveals a major difference between the two languages. American English does not reduce vowels in postonic position, but BP does. The postonic reduction in BP can reach a complete reduction. However, complete reduction is not studied here because it was found to be premature to include such a study within the scope of the present one. Postonic reductions other than complete reductions have c. 25 % decrease. This decrease is accounted for at the word domain by rule 4 with K = .17 in equation (1). The extent of postonic reduction is given a 25 % reduction *relative to the vowel inherent duration* and not relative to a preceding rule operation.

Rule 2 in Klatt's work operates at the phrase level, and is the most difficult to correspond to the present rules. Considering that it is possible to relate rule 2 in Klatt to one of the rules at the sentence domain (rules 8-10), the effect of Klatt's rule 2 is similar to the effect operated by rules 8 and 9. Rules

8 and 9 operate on non-phrase final vowels. The difficulty is that the range of operations done by rule 2 in Klatt is as extensive as the combined effect of rules 4 and 5 in the present study. The large range of situations affected by Klatt's rule 2 is because all situations at the phrase level are kept unaffected. Klatt's phrase final and word final are redundant ("negligible") as two rules and thus Klatt combines them into one (1976, 1216). The speaker of BP distinguishes significantly postonic vowels from phrase final, i.e. clause final, at the acoustic level.

The four rules (4, 5 at the word level, and 8, 9 at the sentence level) related to rule 2 in Klatt may eventually become one or two rules only. It is necessary to continue emphasizing that the present work divides the sentences according to *pauses* primarily, and only secondarily looks at the syntactic boundaries. This results from attempting to stay as close as possible to the nature of the oral narrative.

Rules 3 and 4 for vowels in Klatt's model are related to word size. The speaker in the present study did not show significant duration differences in vowels in relation to word size. It may be that the rate of speech of BP has some influence in neutralizing word size factors. There are no experimental studies on this factor in BP. Preliminary attempts were made in the present study to observe if there were significant differences in duration between monosyllabic and polysyllabic (bysyllabic, trysyllabic included). Polysyllabic words were on the average 30% longer than monosyllabic words. But one should be cautious about this difference, because monosyllabic words in the present study are predominantly function words, and may bias the data. Thus, rules have not been proposed to account for word size factor.

Stressed vowels in Klatt's model seem to be derived by a non-application of rule 3. In other words, the *longest inherent* duration remains unchanged, producing a long vowel which is equivalent to a stressed one. For stressed vowels, rule 7 of the present rules almost doubles (90 % increase) the duration of the stressed vowel by $K = 4$.

In sum, there are three rules in the present study that have no counterparts in Klatt's rules. They are in the sentence domain (rule 10) and in the semantic domain (rules 11 and 12). Eight rules in the present study will be reduced in number as the present investigation continues. In Klatt there are four rules, and his rules "account for 97% of the total variance for each vowel" (1976, 1216). The present rules work similarly. Finally, in Klatt's rules nine parameters are used to predict average vowel duration in 56 situations (1976, 1217); in the present study 14 parameters predict average vowel duration in 64 situations.

5.7. Summary of chapter 5

This chapter compares Klatt's model to the present one with a discussion of each linguistic domain, as a preliminary step for the application and evaluation of the model presented afterward.

As for American English each linguistic component in connected speech shows that duration carries significant information about the organization of language, language processing, and language change. It remains to be shown whether listeners are aware of durational patterns. So far the present study establishes a path for future work in understanding the basic speech production mechanism. The four domains studied interact cyclically from phonological and phonetic domains, into word domain, the syntactic domain, and finally semantic domain.

The main differences and coincidences between Klatt's results and the present ones are as follows. At the acoustic level the closest American English corresponding vowels to the vowels studied here are: [ι, ae, *a*, ω, u]. Although the discussion deals with these comparisons in acoustic terms, this summary presents an articulatory description that is theoretically possible to correlate to F1 and F2 movements. Thus, the front, high [ι] of PM corresponds more closely to American English front, high, non tense [ι]. Phonetically PM's vowels [a, ω] have no counterparts in American English. PM's [a] is midway between American English [ae] and [*a*], in terms of fronting (F2 movements). PM's [ω] is closer to American English [ω] than to [u]. By observing F1 and F2 movements of the three vowels in the present study and the five American English vowels, American English vowels demand greater articulatory effort causing longer duration.

Another difference lies in the stressed : unstressed ratio. The S : U ratio in PM's speech is greater (> 2:1) than in American English (< 2:1). From the analysis of fricative /S/, postvocalic consonant shorten vowels in PM's speech when /S/ is realized as voiceless [š].

Word position in the speech of PM shows four groups which have to be distinguished: two kinds of pretonic, one postonic and the stressed position. Syntactically the vowels increase at the end of some syntactic units and decrease in medial position. In sentence initial position there is no durational change. At the semantic level it was found that topicalization, emphasis, lexicon novelty and exclamatory words increase significantly vowel values. However, it is unlikely to separate these categories within the semantic domain. In a first approach rules were proposed for two categories only: emphasis and topicalization in one category and exclamatory words in another.

The adapted model in this study can successfully predict the durations of the oral vowels at all situations studied in the chosen text. To test such a prediction, at first sentences from the original text were taken randomly and the present rules were able to output all durations within a given interval of [-2 SD to +2 SD] of a normalized curve. A more difficult evaluation is in the prediction of the retelling of the story. The retelling of the story needs minor adaptations, e.g. the value of K at the beginning of sentences needs to be changed for a significant lengthening which had not been observed in the reading of the story.

There are four rules in Klatt's model which do not take into consideration the semantic domain. The present study considers the semantic domain in a first approximation and suggests 12 rules which are expected to be reduced to a fewer number of rules because the existing redundant rules will eventually be eliminated. However, such a reduction in number of rules is to be realized through perceptual validation of the acoustical rules proposed here.

Chapter 6. Conclusion

6.0. Introduction

An acoustical analysis of the three extreme oral vowels /i, a, u/ of Brazilian Portuguese has been conducted. These three vowels were excised from the content of a narrative. Although duration of vowel sounds is not phonemic in Brazilian Portuguese, a thorough analysis of their temporal organization in continuous speech reveals pertinent information about the many linguistic components studied here: phonological and phonetic domain, word domain, syntactic domain, and semantic domain. The study of other factors, including discourse and intonation, was completed by a limited approach because inclusion of more factors would have been improper at the present stage of the research. A later expansion of the present study will include such factors. In this respect, the present study aims to establish a solid basis for future work that will propose more principles for describing BP from an experimental approach.

6.1. Concluding observations about the temporal organization of the vowels analyzed in the present study

The objectives of this dissertation are threefold. The first is to observe how language components affect shortening and lengthening of the three vowels [ɪ, a, ʊ] in one speaker of BP. The findings indicate that sound-segment duration at the acoustic domain differentiates (1) a stressed from an unstressed or reduced vowel, (2) the four word positions: pretonic, stressed, postonic and word initial position, (3) voiced from voiceless postvocalic dental fricative from underlying /S/, (4) presence of a pause not physically present in specific syntactic boundaries (prepausal lengthening of non-word final vowels), and (5) presence or absence of emphasis.

In particular, the results reveal that at the phonological and phonetic domain (1) the postvocalic [s] reduces by some 40-100% the preceding vowel, and (2) there is a stressed:unstressed ratio of 120:52 msec which can indicate a stress-timed rhythm in the analyzed speaker.

At the word domain the postonic position is the weakest. In strong positions the least strong is the pretonic immediately before the stressed, the medial strong is the second pretonic before stressed, especially if it begins with a consonant in word initial position, and the strongest is the stressed position.

At the syntactic domain, the analysis observes significant durations at the following syntactic points: (1) the sound-segments inside a word before embedded sentences, (2) independent sentences, or non-restricted clauses, and at phrases heading complex embeddings (... sentence-3 $\subset$ sentence-2 $\subset$ sentence-1 $\subset$ NP).

At the semantic domain PM's speech was influenced by the same semantic factors that influence American English: emphasis, topicalization, and lexicon novelty. Not surprisingly, it was observed that lexicon novelty made the speaker give extra duration to vowels of less frequent words when the speaker was not familiar with the text. Thus, lexical novelty affects sound-segments duration to a lesser extent as the speaker becomes more familiar with the words.

The second objective is to perform an analysis of how the factors (linguistic components) interact. The interactions of the factors studied were observed by modeling BP. In addition, a number of rules are proposed, applying cyclically from inner units (phonemes) to outer units (sentences). Sometimes only one of these factors influence vowel duration, but usually two or more operate. These rules apply on four domains only; if other domains were added (discourse, for instance) new rules would be required to cover the wider range of possibilities.

The third and last path to be taken was the proposition of rules for the case of the speaker in this study, stemming from D.H. Klatt's (1976) model. Because of phonotactic limitations of BP to the use of Klatt's rules, several adaptations were needed. First, inherent vowel duration cannot be derived by the same technique applied to American English. The twelve rules of this study accurately predict the duration of the three vowels of the speaker PM. However, spontaneous speech needs more changes in the values of K in equation (1).

The methodology developed here needs to be emphasized because of its usefulness and because it has been extensively tested in recent years. One of the results of the lengthy use of the present method is the rules for manual segmentation. Manual segmentation was developed keeping in mind a smooth transition from manual into automated rules in the future. Thus, following current trends in phonetics (Cole and al, 1980; Cole and al, 1983; Elman, J.L. and J.L. McClelland, 1983) manual sound-segment rules were developed for future application either in classroom work on acoustics of speech or in automatic segmentation of speech.

The above mentioned results *per se* have limited use for teachers of Portuguese. For teaching purposes the application is limited to the results on the type of rhythm patterns found. The interest of this research lies mainly (1) in the more recent trends in phonetics such as speech synthesis-by-rule, automatic recognition of continuous speech, and artificial intelligence, and (2) in preparing solid experimental basis for similar works. The methods developed and the testing of these methods are expected to be of use to other investigations of the kind. The present status of the investigation, however, allows for relatively easy and empirical extension into teaching areas. First, it must be decided what is of interest for teaching BP. Then a study of a particular topic of interest can be made, using the same instruments and methods of data analysis as used in this study.

6.2. Contributions and limitations of the present investigation

The work in this dissertation is intended to contribute to the development of experimental studies in Brazilian Linguistics. The analysis of continuous speech and the application of models as explanatory tools are the primary aspects of the present work. In the design of the analysis, the rules for spectrographic analysis should be highlighted because of consequences for classroom work with speech analysis. The results pointed out both the limitations and the possibilities of Klatt's model in terms of language universals.

The present investigation contributes, then, to at least four areas of linguistic analysis. At the area of descriptive analysis it was observed that the speaker analyzed shows general traits of BP and that traits specific of the speaker may be generalizations of BP. For example, the reduction of vowels followed by a voiceless fricative, is a shared trait of the informant's speech and BP in general, and may be a universal trait. Informant specific (speech), and possibly a feature of BP, is the approximant (Ladefoged, 1975, 54) characteristic of the velar consonant /x/. Another finding of the present study at the descriptive level is the complete reduction of sound-segments in postonic position which ranges from the deletion of one sound-segment to the whole syllable. The quality of the vowels studied is different from what is expected. This observation suggests a need to further study vowel quality in BP.

A second contribution concerns the possibility of linguistic change in BP. The possibility of change is raised by the findings of the present study on the approximant characteristics of the velar /x/, the postonic complete reduction of postonic vowels and the quality of the vowels /i/ and /u/, together with the rhythmic play between stress- and syllable-timed rhythm.

A third contribution is found in the methodology developed for measurement of connected speech. Analysis of spectrograms containing isolated spech segments has been done extensively and most of the theory in general phonetics is based on results of isolated speech. However, connected speech is far more complex not only in its interpretation but also in the production of interpretable data. The present study has developed and applied a method for spectrographic analysis of connected speech.

The role of duration in the speech of a BP speaker is a fourth contribution. This is the first study of its kind in BP and reveals the patterns underlying durational changes at four linguistic levels. The work also demonstrates the extension of Klatt's model to a non-English model. Similar work has been reported with Swedish (Lindblom and al, 1981; Lyberg, 1979, 1981). Klatt's model is more readily applicable to CVC languages. CV languages as, it is the case of BP, require a few changes. For example, the definition of inherent duration is problematic. First, the term *unmarked* duration is preferred, instead of inherent duration. Secondly, only CVC languages will be able to excise the "inherent" duration because in Klatt's method an inherent vowel duration is obtained in a context where a voiced stop consonant follows the vowel, as in "big." The phonotactics of BP allows only for liquids and fricatives in postvocalic position. The solution set forth in the present work is to take the grand median of each vowel.

In sum, the present work has developed a methodological framework both in descriptive and empirical language analysis. This methodological framework and its results are expected to make a contribution to areas such as experimental and applied linguistics, speech synthesis-by-rules, automatic verification and recognition of the speaker, use of models in linguistic analysis, all of which are relatively unexplored in Brazilian linguistics.

The present investigation has several limitations. One is the use of the reading of text to generate speech samples for analysis. The reading of a text is an unidirectional linguistic act in the sense that the speaker is less concerned about conveying his message because he has no communication partner. Such an unidirectional approach has limitations; the most important one observed in this study is that the syntactic units are less signaled in his reading than was expected according to Klatt's (1976) predictions.

This limitation can be overcome by an experimental study recording at least two subjects in fluent conversation. However, such goals must be preceded by pilot studies. For example, the present study started using isolated syllables. Then, it proceeded into the use of carrier sentences (Simões, 1980). Finally, a couple of works using connected speech were completed before the present one was undertaken. As one can see, this study has reached progressively more complex stages.

The text chosen also forces a limitation on the present study. It restricts the analysis to a vocabulary for children. The text was chosen in order to have the speaker at ease during the reading, so that less frequently used vocabulary would not interfere. This is a limitation that now can be avoided. A more open vocabulary would reach other linguistic levels with more certainty, and would allow for other observations, e.g., word novelty.

Another limitation is the use of one speaker, which could not be avoided. The work performed in this type of analysis is time consuming. To use two or three speakers producing around one thousand words text each, for example, would make the task unecessarily difficult at this point. Thus one is left either with the use of one speaker producing over a thousand words text or three speakers, each producing some 350 words text.

Both methods have their limitations. Using one speaker allows for no comparisons, an advantage that is always enlightening. Using three speakers, one finds comparisons, but the corpus is relatively small and less reliable for statistical treatment. Naturally, all this does not preclude from attaining the goal of adding more speakers, and a bigger corpus in future works.

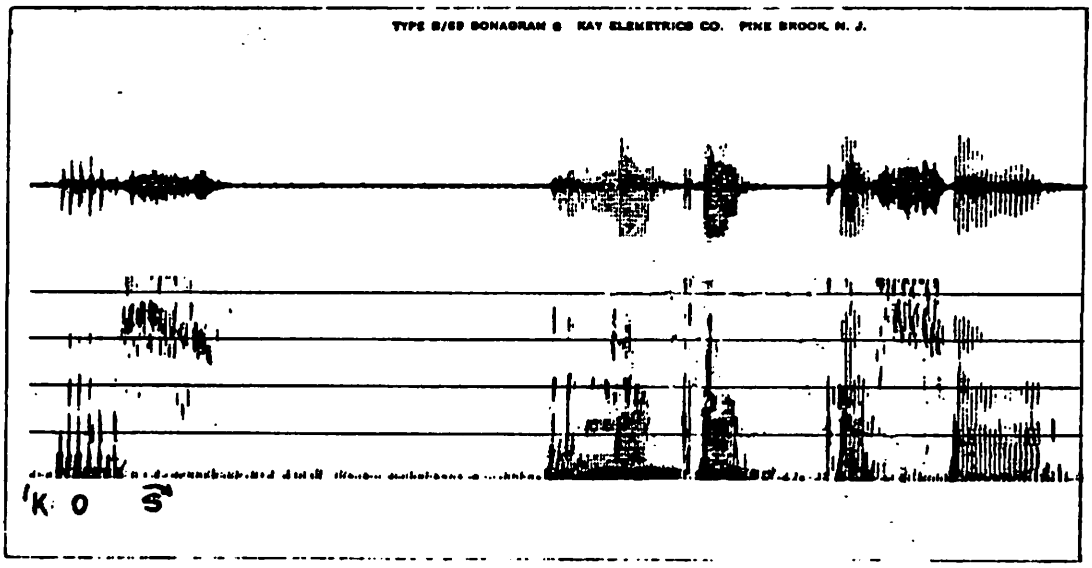
6.3. Suggestions for future research

Several paths of study were uncovered during the years in which the present research took place. All concern facts about BP that can be found only in continuous speech.

At first, complete reduction of vowels in postonic position is considered. There is a high number of cases where vowels were completely reduced because of factors such as phonology, word level and syntax. The interpretation and proposition of rules reflecting the predictablility of these extreme reductions were not attempted in the present investigation. Like other results here, complete reduction of postonic elements indicates a possible phonetic change occurring in BP. Naturally, we are dealing with an observation made with reservation. However, it is a suggestion to be taken into consideration because the number of words analyzed allows for it, despite the use of only one speaker. It would be of interest to examine the quality of vowels preceding the reduced vowel as a way of knowing if the speaker has programmed the completely reduced vowel. The speaker may or may not have the intention of realizing the vowel. The final work of such a study is to use perceptual tests to see if subjects hear the vowel when it is completely reduced.

The acoustic images of cases with completely reduced vowels show that the preceding consonant, especially if it is a fricative consonant, contains acoustic information that the consonant is followed by a vowel. This is illustrated by Figure 18 which shows the word "pescoço" [peš.'ko.s:] without a final vowel; however, the final voiceless fricative [s] has a strong transition toward the F2 of a central vowel. This phenomenon observed during the preliminary analysis of the recordings has not been discussed in detail, but it deserves attention in future investigations of this kind with BP. Studies on coarticulation and its perceptual correlates may be the area of primary interest for such an investigation. Researchers (e.g. Parker and Diehl (1984) have already touched upon similar phenomena.

Figure 18: The word "pescoço" [peš.'ko.s:] in the sentence "Cadê seu pescoço?", has a final [s] with a strong negative transition toward the F2 of a central vowel.



There is another topic for analysis which, if explored, may explain why the present study did not find the expected difference in duration of segments in the narrative versus segments in the dialogues. One feels inclined to give a simple answer to this finding; namely, this is an artifact created by the recording methods. However, it may be worth looking at the domain of discourse factors, by using a different text having dialogues with more expressive sentences. It may be that duration does not play a role in distinguishing different types of discourse. Perhaps intonation is the main factor that accounts for the different styles found in a narrative and a dialogue.

Final lengthening has been linked to change in speed of Fo (Umeda, 1976; Lyberg, 1979). Although intonation is not fully studied here, it was experimentally established in the case of this speaker that sentence final intonation, observed at the stressed syllable, has systematically a falling intonation. In this study it is not possible to correlate the intonation contour with durational patterns. *On the average* it can be said that in sentence final position there is some lengthening and a systematic falling intonation. What makes it difficult to discuss in terms of correlation is that each contour configuration in this study shows any of the three: shortening, lengthening or none. Table 7 below contain some of the many examples.

Table 7: Examples from the text show that possibly there is no correlation between intonation and sound-segment duration. This speaker does not show any clear relation between duration and contour types.

9. cha'mar →	(flat, no durational change)
18. desprote'gida →	(flat, durational decrease)
25. sen'tir →	(flat, durational increase)
4. 'vida ↓	(falling, no durational change)
5. 'sabem ↓	(falling, durational increase)
21. bicha'rada ↓	(falling, durational decrease)
19. sus'pira ↑	(rising, no durational change)
30. te'rrivel ↑	(rising, durational increase)
27. 'vive ↑	(rising, durational decrease)

The present investigation attempted to adapt the work of Klatt (1976) on American English to the speech of a Brazilian Portuguese speaker. The objective has been partially attained. The points where adaptation of Klatt's work were not possible reflect differences between both languages. However, one aspect of Klatt's work, word size, could not be explored in the present study because it was not found significant in the speech analyzed. Moreover there are no studies of BP analyzing the factor word size. Such studies remain as topics for future investigation.

Klatt has made progress in his work, as his more recent articles have shown. He analyzed different parameters as well as levels of analysis different from the acoustic of speech, and the same path can be followed again. The continuation of his work includes application of results from duration into speech synthesis-by-rules, explanation of facts observed by studies in perception and articulatory phonetics, and more recently, studies on intonation (personal communication).

There are other works attempting to model and explain linguistic phenomena related to duration. The most important was a study of Swedish by Lindblom and al (1981). Lindblom and al (1981) offer a more complex analysis in their study of the temporal organization of Swedish. It is a model which expands Klatt's (1976) linear equation to include other factors, such as the number of syllables preceding and following the stressed syllable. Duration change is then affected by the number of syllables preceding or following a given point. The Lindblom and al (1981) model is based on two main equations, one for prediction duration at the word level, and another at the sentence level, these being the two levels considered in their work. For Brazilian Portuguese the work of Lindblom and al (1981) may be revealing in at least one case: the treatment of stress patterns. Stress patterns in their study of Swedish seem to coincide with the patterns of word positions in the present study. In their work, strong concentration of energy occur every other syllable, paralleling the four word positions observed here. The speaker seems to distinguish two pretonic positions. In Lindblom and al this is reflected by giving the syllable closest to the stressed syllable a weak energy, or weak stress, and to the syllable second to the stressed one a stronger stress, and so on. In other words, syllables numbered "1" below, are weak in energy, and syllables numbered "2" are stronger.

... syllable 2 + syll 1 + STRESSED + syll 1 + syllable 2 + ...

The original goal of this study was to provide an *explanation*, as I understand the word, to lengthening and shortening of vowels in continuous speech. The limitation of the analysis to the acoustical level made this original goal premature. There is, however, the interpretation of these phonological process and the application of the model were realized as originally intended. The addition of works at the same and different levels to the present work, should lead to an explanatory tool for the principles governing BP.

APPENDICES

Appendix 1. The Original Text

The text used in the recording sessions is entirely reproduced below, in standard orthography.

O sonho de Carolina

Vera Campos Ferrão, in *Elos de esperança*

Carolina, a minhoca, tem dois grandes desgostos na vida -- ser careca e não ter cintura.

Como todos sabem, a minhoca, coitada, é um bichinho da terra que não tem nada de bonito, nada de especial que possa chamar a atenção de alguém. A cabeça, completamente lisa, não tem um só fio de cabelo. O corpo é aquela coisa toda igual, sem um único sinal do que se poderia chamar de cintura.

Assim é Carolina. E por ser assim, muito infeliz se considera completamente desprotegida pela natureza, suspira invejosa quando vê um pássaro exibindo sua plumagem, ou quando observa os requebros faceiros da Formiga, dona da cinturinha mais fina do Reino da Bicharada.

- Ah, quem me dera ter cabelos! Quem me dera ser dona de uma linda cintura!

E por se sentir tão insatisfeita com a própria figura, com a forma que Deus lhe deu, Carolina vive sempre muito triste.

Quando há festa, dá sempre um jeito de não comparecer, dizendo estar muito atarefada, alargando sua toca, ou então, inventa que tem uma terrível dor de pescoço.

O macaco caçoa:

- Que pescoço, Carolina? Cadê seu pescoço? Você é toda tão igualzinha que nem isso tem. Mais parece um canudinho de refresco!

Carolina, amuada, enterra-se ainda mais em sua toca na terra, teimando em não ir a parte alguma.

A cada dia que passa aumenta o seu humor. Sempre sozinha, torna-se cada vez mais resmungona e esquisita.

Certo dia, passa por ela a Taturana e arrisca um cumprimento:

- Bom dia, Carolina.

- Bom dia coisíssima nenhuma! responde a minhoca com maus modos.

- Mas o que é isto, Carolina? Então não há de ser bom o dia que Deus nos manda cheio de calor, com o sol brilhando na mata, onde podemos respirar e viver em liberdade?

- Isso diz você, só porque é peludíssima como é. Se fosse lisa e careca como eu, queria ver como iria se sentir.

- Mas não vejo razão pra tanto desespero. A Tartaruga é careca como você, além de ser cascuda, e vive toda feliz paquerando o Jabuti.

- Bolas pra você, pra Tartaruga e até pro Jabuti!

Dito o desaforo, Carolina sai tão apressada que dá um encontrão no

Lagarto que vai passando abraçado com sua namorada, a Cobra.

- Ora veja só, resmunga, não sei o que o Lagarto acha nessa Cobra. Careca e sem cintura como eu.

Dona Coruja, meio cochilando sobre um tronco de árvore, abre os olhos sonolentos e comenta:

- Quem ama o feio, bonito lhe parece.

- Já vem a senhora com seus sermões! Ora, vá dormir. Sua hora de acordar não é à noite?

- Conforme-se com o que Deus lhe deu, Carolina. Poderia ser pior.

- Pior!!! E demais! explode a minhoca ziguezagueando de raiva. Com essa, volto pra baixo da terra, de onde nunca deveria ter saído. Passe muito bem!

Linda tarde de sol. Segue Carolina, como sempre triste, pela estrada que leva à sua toca. Vai de cabeça baixa, pensativa. E quando dá com os olhos numa pena de grauna, caída no chão. Nasce uma luminosa idéia:

- Até que enfim, parece que acabo de encontrar a peruca de que tanto precisava. Preta, sedosa, linda. Adeus careca!

Leva a pena para casa, e a transforma numa peruca de franja.

- Com isso, fica só faltando uma coisa. A cintura. Como conseguir afiná-la?

Tanto pensou que acabou por se lembrar de que tinha visto a Formiga jogar no lixo um dos seus célebres espartilhos. Pé ante pé, vai à casa da formiguinha. Encontra a lata de lixo. Vira cá, vira de lá e acaba encontrando.

Até que enfim, o segredo de uma linda cinturinha. Está muito velho, mas saberei como dar um jeito.

Em casa conserta o espartilho até ficar em condições de ser usado. Põe-se diante de um caco de espelho, e vai compondo a figura de uma nova Carolina:

- A peruca assim grudada com cola-tudo está mesmo bacana. Estou até parecida com a tal Cleópatra, rainha do Egito. E a cintura... Uff! Como está apertada! Nada como um espartilho. Bem que vale o sacrifício.

Satisfeita com a nova aparência, passa aos últimos arranjos. Oculos escuros, sapatos de saltos altos, sombrinha vermelha, aberta.

Feliz, lá vai pela estrada ensolarada.

Ao passar pelo Gafanhoto, recebe o primeiro gesto de aprovação:

- Oba! Coisinha fofa!

Vaidosa, Carolina força um requebro e continua gingando pelo caminho.

Dona Coruja, que a tudo observa de seu posto avançado, comenta:

- Tirando suas casquinhas, ein [sic], Gafanhoto?

- Ah, dona Coruja, a senhora estava aí?

- Estava e estou.

- Ela até que é bacana, não acha?

- Ela, quem?

- Ela... Ela... a... a... Sei lá. Quem é ela, afinal?

- Não sei. Você sabe?

- Também não. E exótica, diferente. Não se parece com nenhum dos bichos do Reino... Ou será que parece? Não sei bem...

- Hum... isto dá muito no que pensar. Seria capaz de jurar que já vi essa coisa antes... Será quem estou pensando? Mas também pode ser que não seja. Hum... sei não... Deixa pra lá. Quer saber? Por uma questão de cautela, acho melhor levar o caso ao conhecimento de nossa rainha, a Onça.

- Sempre raciocinando com sabedoria, dona Coruja. Não é à toa que a bicharada toda gosta de ouvir seus conselhos. Vamos depressa falar à rainha.

E bem depressa vão.

- ...e rogamos a V. Majestade, tome providencias a fim de proteger nossos filhotes contra essa coisa estranha que acaba de aparecer em seus domínios. Tenho dito!

Debaixo de uma salva de palmas da bicharada, dona Coruja acaba seu discurso dirigido à rainha, em defesa do interesse de todos.

- Contem comigo, ruge a Onça, contem comigo! Não decepcionarei meus súditos.

- Bravo! Viva a Onça! Viva!!!

Aplausos de todos os cantos. Aprovações em todas a bocas. Mas, em todas mesmo? Bem... em quase todas. Falta só a de Carolina. E que ela, completamente por fora dos acontecimentos, está admirando sua nova figura refletida nas águas do lago.

- Eta espelho legal. Tô linda demais!

Enquanto isso, os animais traçam planos de defesa contra a estranha invasora. Ocupando cada qual o seu esconderijo, ficam esperando o aparecimento da fera.

A minhoca estranhando tanto silencio e, pela primeira vez, desejando encontrar algum bicho em seu caminho, vai seguindo pela estrada principal. Claro, sem esquecer o rebolado e sempre sombrinha aberta.

- Silêncio! Lá vem a coisa, avisa dona Coruja.

- Deixem pra mim, ordena a Onça.

E trata de por garras à obra. Uma rede tecida com fios de teia de aranha e lançada em cima de Carolina.

A coitada, desesperada, esperneia:

- Soltem-me! Deixem disso! Eu sou a minhoca Carolina, olhem pra mim. Não estão me reconhecendo?

Tenta arrancar a peruca. Muito bem colada, teima em não sair.

- Larguem-me! Sou Carolina, não estão vendo?

- Mentira! grita o Macaco. Mentira mesmo! A minhoca é careca e acinturada como uma içá.

- Pois espere só pra ver, e insiste a minhoca, arrancando a saia e o espartilho.

Um "Oh!" de espanto ecoou pela selva. E no silêncio que se segue, ouve-se a minhoca prisioneira suspirar:

- Uff! Que alívio! Eta espartilho apertado!

E virando-se para o Macaco:

- Por favor, lave minha cabeça com água de coco, sim?

O Macaco olha para a Onça. Esta faz um sinal de consentimento. À medida que a água vai escorrendo pela pena de graúna, ela vai se soltando e deixando à mostra a triste calvície de Carolina.

Decepção para o Gafanhoto paquerador. Espanto geral. Apenas dona Coruja arrisca um comentário:

- Tava na cara. Essa minhoca nunca me enganou.

Appendix 2. The original text having the measurements inserted

This text has the durations of phonetic [ι, a, ω] vowels. This breakdown is based on occurrences of pauses made by the speaker. The syntactic units are obtained by means of native speaker intuition. Some strings of words were not categorized as sentences. These strings of words do not contain the "S[ ]E" indicators (cf. convention b. below). The immediate constituents must have either explicitly or implicitly some sort of connector ("e" ("and"), "quando" ("when"), and so forth. Both standard orthographic and broad phonetic representations of the text are used.

Conventions:

a. (|) means a short pause, < 32msec (< 4mm)

(||) means a moderate pause, [32-80]msec ([4-10]mm)

(|||) means a long pause > 80msec (> 10mm).

b. S[means whole sentence starts

]E means whole sentence ends

/ means immediate constituent or non-restrictive clause

==> means "continued"

1. (...terceir[a13.5] leit[ω14.]r[a6.5] d[ι25.5]:) ||
2. [ω9.5] sonh[ω7.] d[ι3.5] C[a13.5]rolin[a8.] |||

Vera Campos Ferrão, in *Elos de esperança*

PARAGRAPH ONE

3. S[C[a15.5]rolina, [a10.] minhoc[a6.], ||

4. tem dois grand[ι12.]s d[ι7.5]sgost[ω3.5]s n[a6.5] v[ι10.5]d[a1.] || /

5. -- ser c[a17.5]rec[a8.] |

6. [ι5.] não ter cint[ω15.]r[a5.]. ||]E

7. S[Com[ω3.5] tod[ω5.5]s s[a16.5]bem, || /

8. [a11.5] minhoc[a7.], ==> / coit[a19.5]d[a6.5], || /

9. ==> é um b[ι6.]chinh[ω5.] d[a13.] terr[a7.] qu[ι7.] não tem n[a13.5]d[a4.5]

d[ι9.5] b[ω9.5]n[ι11.]t[ω1.], ||

10. n[a29.5]d[a5.5] d[ι0.0] [ι2.]special qu[ι2.5] poss[a2.5] cham[a11.]r [a0.0]

[a6.5]tenção d[ι4.] alguém. ||]E

11. S[[a7.5] c[a8.]beç[a3.], ==> || /

12. complet[a7.]ment[ι13.] l[ι16.5]s[a5.], ||

13. ==> não tem um só fio d[ι7.] c[a6.5]bel[ω1.]. ||]E

14. S[[ω14.] corpo é [a4.]quel[a6.5] cois[a4.0] tod[a1.] [ι7.5]gual, ||

15. sem um [ω8.]n[ι5.]c[ω5.] s[ι3.5]nal d[ω5.5] qu[ι10.] s[ι1.5] poderia

ch[a5.]m[a13.]r d[ι3.] cint[ω17.]r[a3.]. |||]E

PARAGRAPH TWO

16. S[[a14.]ssim é C[a14.]r[ω12.]lin[a.5]. |||]E

17. S[[ι8.] p[ω11.]r ser [a11.]ssim, ||

18. muit[ω8.5] infel[ι10.5]z s[ι4.5] cons[ι5.]der[a5.] | (very short

19. complet[a6.5]ment[ι9.5] d[ι1.]sproteg[ι4.]d[a3.] pel[a7.5]

n[a9.]t[ω9.5]rez[a.5], || /

20. s[ω7.]sp[ι11.5]r[a6.5] invejos[a3.] quand[ω7.] vê um p[a15.]ss[a2.]r[ω1.5]

ex[ι4.5]bind[ω3.] sua plum[a17.]gem, || /

21. ou quand[ω3.] observ[a5.5] [ω4.5]s requebr[ω3.5]s f[a6.]ceir[ω9.]s d[a7.5] F[ω6.]rm[ι12.5]g[a3.], || /

22. don[a9.] d[a6.5] cint[ω9.]rinh[a9.] mais fin[a8.] d[ω7.5] Rein[ω7.5] d[a6.]

B[ι3.5]ch[a10.]r[a7.]d[a7.5]. ||]E

PARAGRAPH THREE

23. S[- [a28.5]h, ||

24. quem m[ι6.5] der[a5.5] ter c[a11.5]bel[ω13.5]s! ||]E

25. S[Quem m[ι4.5] der[a8.] ser don[a9.] d[ι5.5] um[a8.5] lind[a6.5]

cint[ω18.]r[a2.5]! |||]E

26. S[[ι8.] p[ω11.5]r s[ι4.5] sent[ι19.5]r | (very short pause)

27. tão ins[a12.5]t[ι10.]sfeit[a7.] com [a3.5] própria f[ι4.]g[ω11.5]r[a4.5], |

28. com [a8.] form[a5.5] qu[ι7.5] Deus lh[ι7.] deu, || /

29. C[a16.5]r[ω11.]lin[a6.5] v[ι8.]v[ι7.] sempr[ι2.] muit[ω6.5]

tr[ι14.5]st[ι6.]. ||]E

30. S[Quand[ω3.] h[a8.] fest[a8.], ||

31. d[a11.5] sempr[ι2.] um jeit[ω6.5] d[ι10.] não comp[a9.]recer, ||

32. d[ι8.5]zend[ω.0] [ι6.5]st[a14.5]r muit[ω.0]

[a9.]t[a9.5]ref[a20.5]d[a5.5], | (very short pause)

33. [a2.]l[a14.5]rgand[ω3.] sua toc[a10.], || /

34. ou então, ||

35. invent[a6.5] qu[ι5.] tem um[a6.] terr[ι19.5]vel dor d[ι6.5] pescoç[ω0.]. ||
]E

36. S[[ω6.5] m[a8.5]c[a15.5]co c[a9.5]çoa: ||

37. - Qu[ι10.] pescoç[ω2.], C[a12.]r[ω9.]lin[a2.]? |

38. C[a9.]dê o seu pescoç[ω0.]? ||]E

39. S[Você é tod[a10.5] tão [ι12.5]gualzinh[a2.] qu[ι7.] nem [ι7.]ss[ω3.]
tem. |]E

40. S[Mais p[a10.5]rec[ι4.5] um c[a9.5]n[ω8.]dinh[ω4.5] d[ι10.] refresc[ω1.]!
||]E

41. S[C[a19.]r[ω16.5]lin[a5.5], [a5.]muad[a4.], ||

42. enterr[a7.5]-s[ι9.] aind[a5.5] mais em sua toc[a5.] n[a5.]
terr[a5.5], | (short pause)

43. teimand[ω.0] em não [ι8.5]r [a6.5] p[a10.]rt[ι6.5] algum[a8.]. ||]E

44. S[[a6.5] c[a10.]d[a7.] dia qu[ι9.5] p[a19.5]ss[a.5] ||

45. aument[a4.5] [ω4.] seu h[ω11.5]mor. ||]E

46. S[Sempr[ι5.5] sozinh[a4.5], ||

47. torn[a7.5]-s[ι4.5] c[a13.5]d[a12.5] vez mais resmungon[a5.5]
[ι4.5] [ι2.5]squ[ι7.]s[ι15.5]t[a1.]. ||]E

PARAGRAPH FOUR

48. S[Cert[ω9.5] dia, ||

49. p[a13.]ss[a6.5] p[ω12.5]r el[a.0] [a9.] T[a10.5]t[ω11.5]ran[a5.5] || /

50. [ι5.5] [a10.5]rr[ι9.]sc[a1.] um cumpr[ι5.]ment[ω1.]: ||

51. - Bom dia, C[a10.]rolin[a1.]. ||]E

52. S[- Bom dia, cois[ɩ19.5]ss[ɩ1.]m[a4.5] nenhum[a9.]! respond[ɩ4.5] [a4.5]

minhoc[a6.5] com maus mod[ω1.]s. ||]E

53. S[- Mas [ω4.] qu[ɩ12.] é [ɩ6.5]ss[ω2.5], C[a14.]r[ω7.5]lin[a1.]? ||]E

54. S[- Então não h[a9.5] d[ɩ12.5] ser bom [ω4.] dia qu[ɩ8.5] Deus n[ω6.]s

mand[a6.] cheio d[ɩ8.] c[a18.]lor ||

55. com [ω4.] sol br[ɩ7.5]lhand[ω5.5] n[a9.] m[a20.5]t[a7.5], || /

56. ond[ɩ7.] podem[ω2.5]s resp[ɩ12.5]r[a21.]r [ɩ6.5] v[ɩ8.]ver em

l[ɩ5.]berd[a21.]d[ɩ6.]. ||]E

57. S[- [ɩ16.]ss[ω7.5] d[ɩ18.5]z você, || /

58. só p[ω6.5]rque | (short pause)

59. é pel[ω11.5]d[ɩ20.]ss[ɩ2.]m[a5.] com[ω6.] é. ||]E

60. S[- S[ɩ4.] foss[ɩ4.5] l[ɩ20.5]s[a1.] [ɩ5.5] c[a16.5]rec[a6.5]

com[ω6.5] eu, | (very short pause) /

61. qu[ɩ11.5]ria ver com[ω3.5] [ɩ9.]ria s[ɩ3.] sent[ɩ22.]r. ||]E

62. S[- Mas não vej[ω5.5] r[a22.5]zão pr[a4.5] tant[ω8.5]

d[ɩ12.]s[ɩ5.]sper[ω3.5]. ||]E

63. S[- [a5.5] T[a8.5]rt[a15.5]r[ω9.5]g[a4.] é c[a17.5]rec[a7.5] com[ω3.] você, | /

64. [a15.5]lém d[ɩ2.] ser c[a9.]sc[ω19.]d[a7.5], || /

65. [ɩ9.5] v[ɩ7.5]v[ɩ5.5] tod[a5.] fel[ɩ5.]z p[a7.5]querand[ω.0]

[ω8.] J[a7.5]b[ω6.5]t[ɩ23.5]. |||]E (Here, the speaker turns the page)

66. - Bol[a9.5]s pr[a7.] você, pr[a4.5] T[a7.]rt[a14.5]r[ω20.]g[a.0] [ι3.] [a7.5]té

pr[ω4.5] J[a10.5]b[ω8.5]t[ι24.] |||

PARAGRAPH FIVE

67. S[D[ι20.5]t[ω.0] [ω7.5] d[ι11.]s[a10.5]for[ω2.] || /

68. C[a17.]r[ω9.]lin[a6.] sai tão [a8.5]press[a14.]d[a7.5] | (very short pause

69. qu[ι7.] d[a9.] um encontrão n[ω9.5] l[a9.]g[a19.]rt[ω2.] qu[ι8.5] vai p[a11.]ssand[ω.0] [a7.]br[a6.]ç[a10.5]d[ω5.] com sua n[a5.5]mor[a20.5]d[a3.5], | (very short pause) /

70. [a15.5] Cobr[a5.5]. ||]E

71. S[- Or[a8.5] vej[a9.5] só, || /

72. resmung[a4.5], || /

73. não sei [ω3.5] qu[ι4.5] [ω7.] L[a9.5]g[a12.]rt[ω11.] [a9.5]ch[a2.5] ness[a4.5] Cobr[a3.5]. || /

74. C[a25.]rec[a.0] [ι7.5] sem cint[ω14.]r[a7.5] com[ω4.5] eu. ||]E

75. S[Don[a6.5] C[ω10.5]r[ω18.5]j[a5.], || /

76. meio c[ω6.5]ch[ι4.5]land[ω3.] sobr[ι.0] um tronc[ω6.] d[ι5.5] [a31.]rvor[ι.0], || /

77. [a14.5]br[ι7.] [ω2.5]s olh[ω3.5]s sonolent[ω4.]s / [ι5.] coment[a7.5]: ||

78. - Quem am[a.0] [ω7.5] feio, b[ω10.5]n[ι11.5]t[ω8.5] lh[ι5.5] p[a15.5]rec[ι1.]. ||]E

79. S[- J[a15.] vem [a8.] senhor[a5.5] com seus sermões! ||]E

80. S[Or[a8.5], v[a13.] d[ω8.]rm[ι17.]r.]E

81. S[Sua hor[a4.5] d[ι4.5] [a7.]cord[a12.]r não é [a5.5] noit[ι17.5]? ||]E

82. S[- Conform[ι8.]-s[ι2.5] com [ω.0] qu[ι5.] Deus lh[ι5.5] deu,
C[a12.5]rolin[a7.5]. |]E

83. S[Poderia ser pior. ||]E

84. S[- Pior!!! ||

85. E d[ι15.5]mais! ||

86. [ι3.5]xplo[ι5.5] [a6.5] minhoc[a12.5] z[ι3.5]gu[ι5.5]z[a11.]gueand[ω.0]
d[ι13.5] raiv[a.0]. ||]E

87. S[- Com ess[a7.] ||

88. volt[ω8.] pr[a5.5] baix[ω0.] d[a11.5] terr[a9.5], / d[ι8.] ond[ι10.]
nunc[a9.5] deveria ter saĭd[ω2.5]. |]E

89. S[P[a17.]ss[ι2.] muit[ω10.5] bem. |||]E

PARAGRAPH SIX

90. Lind[a8.5] t[a13.5]rd[ι8.5] d[ι8.] sol. ||

91. S[Segu[ι.0] C[a15.]r[ω10.]lin[a6.], ==> | (short pause) /

92. com[ω4.5] sempr[ι1.] tr[ι18.]st[ι17.5], || /

93. pel[a.0] [ι5.]str[a14.5]d[a5.] qu[ι7.5] lev[a0.0] [a7.5]
sua toc[a1.]. ||]E

94. S[Vai d[ι8.0] c[a9.]beç[a5.] baix[a1.], pens[a6.5]t[ι22.5]v[a3.]. ||]E

95. S[E quand[ω4.5] d[a12.5] com [ω4.5]s olhos num[a7.] pen[a8.] d[ι11.]
graún[a4.5], |

96. caíd[a7.] n[ω7.] chão. ||]E

97. S[N[a13.5]sc[ι2.] um[a9.] l[ω7.5]m[ι10.]nos[a.0] [ι6.5]déia. ||]E

98. S[- [a8.5]té qu[ι.0] enfim, ||

99. p[a14.5]rec[ι1.] / qu[ι2.] [a10.5]c[a22.]b[ω4.] d[ι5.] encontr[a14.5]r [a5.5] p[ι11.5]r[ω10.5]c[a6.] / d[ι8.5] qu[ι6.5] tant[ω5.] prec[ι4.5]s[a23.5]v[a3.5]. ||]E

100. Pret[a9.], sedos[a9.], lind[a7.] |

101. [a13.5]deus c[a17.5]rec[a9.5]! ||

PARAGRAPH SEVEN

102. S[Lev[a.0] [a7.5] pen[a5.5] p[a8.]r[a9.5] c[a23.]s[4.5] || /

103. [ι3.] [a6.] transform[a4.5] num[a6.5] per[ω10.5]c[a5.5] d[ι9.] franj[a5.]. ||]E

104. S[- Com [ι18.]ss[ω0.], ||

105. f[ι6.5]c[a11.] só faltand[ω.0] um[a9.5] cois[a0.]. |

106. [a4.5] cint[ω24.5]r[a5.]. ||]E

107. S[Com[ω6.] cons[ι5.]gu[ι8.5]r [a7.5]f[(*i4.]n[a21.5]-l[a5.5]? ||]E

108. S[Tant[ω4.5] pensou || /

109. qu[ι7.] [a6.5]c[a11.]bou p[ω9.5] s[ι5.] lembr[a22.5]r / d[ι8.] qu[ι5.5] tinh[a10.5] v[ι6.5]st[ω.0] [a7.] f[ω8.]rm[ι11.5]g[a6.5] jog[a10.]r n[ω7.5] l[ι15.5]x[ω0.] |(very short pause)

110. um d[ω3.]s seus célebres esp[a9.5]rt[ι19.]lh[ω2.]s. ||]E

111. S[Pé ant[ι12.] pé, ||

112. vai [a6.5] c[a14.]s[a6.] d[a5.5] f[ω7.]rm[ι5.5]guinh[a3.5]. ||]E

113. S[Encontr[a0.] [a12.5] l[a8.5]t[a10.] d[ι15.5] l[ι13.5]x[ω.0]. ||]E

114. S[V[ι15.]r[a9.5] c[a22.], ||

115. v[ι9.]r[a10.] d[ι12.5] l[a18.], || /

116. [ι5.5] [a6.5]c[a13.]ba encontrand[ω1.]. ||]E

PARAGRAPH EIGHT

117. [a7.]té qu[ι11.5] enfim! ||

118. [ω4.] segred[ω5.5] d[ι5.5] um[a9.5] lind[a7.5] cint[ω12.]rinh[a7.]. ||

119. S[[ι3.5]st[a10.5] muit[ω11.] velh[ω0.], | (very short pause) /

120. mas s[a6.]berei com[ω5.5] d[a13.5]r um jeit[ω5.5]. |||]E

121. S[Em c[a27.]s[a3.5] ||

122. consert[a.0] [ω4.5] [ι3.]sp[a7.]rt[ι23.5]lh[ω.0] / [a11.5]té
f[ι4.5]c[a12.5]r em cond[ι14.]ções d[ι8.5] ser [ω8.]s[a16.]d[ω3.5]. ||

123. S[P˜oe-se diant[ι9.] d[ι4.5] um c[a18.]c[ω7.5] d[ι4.]
[ι5.]spelh[ω.0], || /

124. [ι4.5] vai compond[ω.0] [a5.] f[ι5.]g[ω9.5]r[a7.5] d[ι6.5] um[a8.] nov[a4.]
C[a12.5]r[ω11.5]lin[a3.]: ||]E

125. S[- [a7.5] per[ω13.]c[a.0] [a10.]ssim gr[ω5.5]d[a11.]d[a7.5] com
col[a8.]-t[ω11.5]do [ι6.5]st[10.] mesm[ω5.5] b[a11.]c[a20.5]n[a4.5]. ||
]E

126. S[[ι0.]stou [a9.5]té p[a12.]r[ι7.]c[ι6.5]d[a8.] com [a3.5] tal
Cleóp[a14.5]tr[a15.5], / rainh[a6.5] d[ω9.] Eg[ι10.]t[ω7.5]. ||]E

127. S[[ι13.] [a4.5] cint[ω16.]r[a6.5]... ||

128. [ω19.]ff! ||

129. Com[ω2.5] [ι2.]st[a5.] [a10.]pert[a27.5]d[a1.]! ||]E

130. N[a18.]d[a8.5] com[ω.0] um [ι3.5]sp[a8.5]t[ι26.5]lh[ω3.5]. |

131. S[Bem qu[ι11.5] v[a15.]l[ι1.] [ω4.5] s[a6.5]cr[ι5.]f[ι10.]cio. ||]E

132. S[S[a7.5]t[ι8.5]sfeit[a7.5] com [a6.] nov[a.0] [a6.]p[a13.]rência, ||

133. p[a16.]ss[a.0] aos últ[ι9.]m[ω5.]s [a11.]rranj[ω.0]s. ||]E

134. Oc[ω14.]l[ω6.]s [ι6.]sc[ω17.5]r[ω2.]s, ||

135. s[a9.]p[a15.5]t[ω1.]s d[ι9.5] salt[ω7.5]s alt[ω1.]s, |

136. sombrinh[a8.5] vermelh[a6.5], [a4.]bert[a.0]. ||

PARAGRAPH NINE

137. S[Fel[ι16.]z, || /

138. l[a11.5] vai pel[a.0] [ι4.5]str[a11.]d[a.0] ensol[a12.5]r[a15.5]d[a1.]. |||]E

139. S[Ao p[a10.5]ss[a8.5]r pelo g[a8.5]fanhot[ω8.5], receb[ι6.] [ω2.] pr[ι3.]meir[ω3.] elogio d[ι3.] [a7.]prov[a8.]ção: ||

140. - Ob[a7.] coisinh[a5.5] fof[a2.]! ||]E

141. S[Vaidos[a3.], || /

142. C[a14.]rolin[a7.5] forç[a.0] um requebr[ω.0] / [ι4.5] cont[ι20.5]nua jingand[ω4.] pel[ω5.] c[a9.5]minh[ω3.]. ||

143. Don[a7.5] C[ω15.5]r[ω19.]j[a.0], ==> || /

144. qu[ι11.5] [a2.] t[ω13.5]d[ω.0] observ[a4.5] d[ι5.5] seu post[/(*w.0]] [a8.]vanç[a17.5]d[ω4.], / ==> coment[a6.]: ||

145. - T[ι15.5]rand[ω2.] suas c[a9.5]squinh[a13.]s, ein, G[a6.5]fanhot[ω1.]? ||
]E

146. S[- [a24.]h don[6.] C[ω7.]r[ω13.]j[a1.], ||
147. [a4.5] senhor[a.0] [ι1.]st[a10.]v[a.0] aí? ||]E
148. S[- [ι4.5]st[a28.5]v[a9.] / [ι16.] [ι8.5]stou. ||]E
149. S[- El[a.0] [a7.5]té qu[ι7.5] é b[10.5]can[a8.5], não [a17.5]ch[a.0]? ||]E
150. - El[a23.], quem? |||
151. - El[a41.]... Ela... a... [a84.]... S[Sei l[a21.]. ||]E
152. S[Quem é el[a.0] [a7.5]f[ι4.5]nal? ||]E
153. S[- Não sei. |]E
154. S[Você s[a19.5]b[ι6.]? ||]E
155. - Também não. ||
156. S[E exót[ι11.5]c[a4.], d[ι8.5]ferent[ι14.]. ||]E
157. S[Não s[ι3.] p[a12.]rec[ι0.] com nenhum d[ω9.5]s b[ι13.5]ch[ω3.5]s d[ω10.] Rein[ω3.]... ||]E
158. S[Ou ser[a12.5] qu[ι5.] p[a13.5]rec[ι2.]? ||]E
159. S[Não sei bem. ||]E
160. S[- Hum... ||
161. [ι7.5]s[ω0.] d[a10.] muit[ω5.5] n[ω6.] qu[ι9.] pens[a15.]r. ||]E
162. Seria c[a10.5]paz d[ι3.5] j[ω10.5]r[a15.5]r / qu[ι4.] j[a10.5] v[ι7.5] ess[a6.] cois[a11.5] ant[ι10.]s... ||]E
163. S[Ser[a13.5] quem [ι0.]stou pensand[ω3.5]? ||]E
164. S[Mas também pod[ι9.] ser / qu[ι4.5] não sej[a2.5]. ||]E
165. S[Hum... sei não... |||]E (Here, the speaker turns a page)
166. S[Deix[a4.5] pr[a7.5] l[a20.5] |]E

167. S[Quer s[a7.]ber? ||]E

168. S[P[ω10.]r um[a8.] questão d[ι4.5] cautel[a4.5], ||

169. [a12.]ch[ω2.5] melhor lev[a10.5]r [ω5.] c[a18.5]s[ω.0] ao conhec[ι2.]ment[ι6.5] d[ι6.5] noss[a7.] Rainh[a5.], | /

170. [a10.5] Onç[a6.]. ||]E

171. S[- Sempr[ι4.] r[a8.5]cioc[ι2.]nand[ω4.5] com s[a5.]b[ι5.]d[ω11.]ria, don[a5.5] C[ω6.]r[ω17.5]j[a6.5]. ||]E

172. S[Não é [a5.] toa / qu[ι4.] [a5.5] b[ι3.5]ch[a12.5]r[a14.]d[a6.5] tod[a10.5] gost[a4.5] d[ι4.5] ouv[ι10.5]r seus conselh[ω.0]s. ||]E

173. S[Vam[ω4.]s d[ι3.5]press[a3.] f[a6.5]l[a12.5]r [a9.] rainh[a5.5]. ||]E

174. S[[ι5.5] bem d[ι9.5]press[a6.] vão. |||]E

PARAGRAPH TEN

175. S[- ... [ι6.] rogam[ω5.5]s [a7.] Voss[a2.] M[a7.5]jest[a22.5]d[ι11.5], || /

176. tom[ι6.5] prov[ι7.]dências / [a8.5] fim d[ι9.5] proteger noss[ω3.5]s f[ι3.5]lhot[ι9.5]s. ||

177. contr[a.0] ess[a4.5] cois[a.0] [ι4.5]stranh[a7.] / qu[ι11.] [a1.]c[a19.5]b[a8.] d[ι5.5] [a6.5]p[a10.5]recer em seus domínios. |]E

178. S[Tenh[ω6.] d[ι17.]t[ω2.]! ||]E

179. S[D[ι11.5]baix[ω6.5] d[ι5.] um[a8.5] salv[a8.] d[ι9.5] palm[a5.5]s d[a7.] b[ι5.5]ch[a12.]r[a19.5]d[a3.], ||

180. don[a6.] C[ω8.5]r[ω11.]j[a.0] [a5.5]c[14.5]b[a2.5] seu d[ι6.5]sc[ω10.]rs[ω2.]

d[ι11.]r[ι7.5]g[ι6.5]d[ω.0] [a9.5] rainh[a7.], ||

181. em defes[a4.5] d[ω3.5] interess[ι2.] d[ι6.5] tod[ω5.]s. ||]E

182. S[- Contem com[ι16.]g[ω8.], || /

183. r[ω10.5]g[ι4.] [a5.] Onç[a7.], || /

184. contem com[ι22.]g[ω6.5]! ||]E

185. S[Não decepcion[a13.]rei meus s[ω12.]d[ι8.]t[ω9.5]s. ||]E

186. S[- Br[a31.5]v[ω20.]! V[ι13.]v[a.0] [a13.5] Onç[a24.5]! V[ι17.5]v[a33.5]! ||]E

187. [a10.]plaus[ω5.5]s d[ι10.5] tod[ω2.]s [ω6.5]s cant[ω1.]s. ||

188. [a13.5]prov[a10.5]ções em tod[a9.5]s [a8.5]s boc[a5.]s. ||

189. Mas, ||

190. em tod[a12.]s mesm[ω1.]? ||

191. Bem... |

192. em quas[ι6.5] tod[a5.5]s. ||

193. S[Falt[a8.5] só [a5.] d[ι9.] C[a14.5]r[ω11.]lin[a2.]. ||]E

194. S[E qu[ι15.5] el[a6.], / complet[a7.5]ment[ι7.5] p[ω7.]r for[a2.5] d[ω5.5]s [a7.5]contec[ι0.]ment[ω1.]s, || /

195. [ι2.]st[a16.] [a3.5]d[ι10.]m[ι10.]rand[ω3.] sua nov[a7.5] f[ι3.]g[ω21.]r[a10.]

refiet[ι14.]d[a7.5] n[a12.]s [a15.5]guas d[ω7.5] l[a21.]g[ω1.]. ||]E

196. - Et[a.0] [ι8.]spelh[ω2.] legal. ||

197. S[Tô lind[a9.] d[ι10.5]mais! |||]E

PARAGRAPH ELEVEN

198. S[Enquant[ω14.5] [ι17.]s[ω0.], ||

199. [ω3.]s [a10.]nimais tr[a11.]çam plan[ω3.]s d[ι6.5] defes[a4.5] contr[a3.] [a6.5] [ι3.]stranh[a.0] inv[a11.]sor[a7.]. |||]E

200. S[Oc[ω6.]pand[ω5.5] c[a10.5]d[a11.5] qual [ω5.] seu [ι2.]scond[ι15.]r[ι16.5]j[ω2.], | /

201. f[ι6.5]cam [ι1.]sperand[ω.0] [a5.]p[a9.5]rec[ι4.]ment[ω6.] d[a8.] fer[a3.5]. ||]E

203. S[[a10.5] minhoc[a5.5] || ==>

204. [ι0.]stranhand[ω.0] tant[ω6.] s[ι8.5]lêncio | / (very short pause)

205. [ι11.5], pel[a5.5] pr[ι4.]meir[a11.5] vez, || /

206. desejand[ω.0] encontr[a9.]r algum b[ι12.5]ch[ω2.5] em seu c[a13.5]minh[ω1.], || /

207. ==> vai s[ι5.]guind[ω2.] pel[a.0] [ι4.]str[a10.5]d[a5.] princ[ι2.5]pal. ||]E

208. Cl[a15.]r[ω3.5], |

209. sem [ι6.5]quecer [ω3.5] rebol[a19.]d[ω1.] ||

210. [ι10.] sempr[ι3.5] d[ι9.5] sombrinh[a.0] [a7.5]bert[a1.]. ||

211. S[- S[ι8.]lêncio! ||

212. L[a9.5] vem [a6.5] cois[a6.], [a7.]v[ι9.]s[a5.5] don[a6.] C[ω7.]r[ω17.]j[a1.]. ||]E

213. S[- Deixem pr[a7.] mim, |

214. orden[a2.] [a6.] Onç[a1.]. ||]E

215. S[[ι10.5] tr[a15.]t[a6.5] d[ι8.5] por g[a17.]rr[a12.5]s [a9.5] obr[a.5]. |||

]E

216. S[Um[a9.5] red[ι9.5] tec[ι7.]d[a7.5] com fios d[ι5.5] teia d[ι10.] [a9.5]ranh[a0.] ||

217. é lanç[a10.5]d[a.0] em cim[4.5] d[ι8.] C[a13.]r[ω7.5]lin[a5.5]. ||]E

218. S[[a7.5] coit[a18.5]d[a5.5], / d[ι7.5]s[ι6.5]sper[a19.5]d[a2.], / [ι4.5]sperneia. ||]E

219. S[- Soltem-m[ι9.]! ||]E

220. S[Deixem d[ι24.]ss[ω4.]! ||]E

221. S[Eu sou [a7.5] minhoc[a7.5] C[a14.]r[ω11.]lin[a11.5], olhem pr[a5.] mim. ||]E

222. S[Não [ι2.5]stão m[ι5.5] reconhecend[ω4.5]? |||]E

223. S[Tent[a.0] [a9.5]rranc[a13.]r [a5.] p[ι9.5]r[ω12.]c[a10.]. ||]E

224. S[Muit[ω5.5] bem col[a17.]d[a9.5], || /

224. teim[a2.5] em não sair. ||]E

225. S[- L[a22.5]guem-m[ι7.5]! ||]E

226. S[Sou C[a14.5]r[ω11.]lin[a6.], / não [ι2.]tão vend[ω3.5]? ||]E

227. S[- Ment[ι37.5]r[a15.5]! / gr[ι18.]t[a6.] [ω2.] M[a9.]c[a20.5]c[ω1.5]. | /

228. Ment[ι26.5]r[a11.5] mesm[ω4.]! ||]E

229. S[[a10.] minhoc[a.0] é c[a16.]rec[a11.5] | /

230. [ι2.5] não tem cint[ω22.]r[a3.]. ||]E

231. S[Você é c[a9.]b[ι12.5]l[ω17.]d[a.0] [ι4.] [a10.5]cint[ω10.5]r[a15.]d[a5.]

com[ω.0] um[a4.5] [ι3.5]ç[a15.5]. |||]E

232. S[- Pois [ι4.5]sper[ι3.] só pr[a7.] ver, || /

233. [ι4.5] ins[ι8.]st[ι8.5] [a2.5] minhoc[a10.], ||

234. [a4.5]rrancand[ω.0] [a8.5] saia [ι4.5] [ω3.5]

[ι8.]sp[a4.5]rt[ι23.5]lh[ω.5]. ||]E

235. S[Um |

236. "Oh" d[ι11.] [ι8.5]spant[ω8.] [ι4.5]s... |

237. ecoou pel[a7.5] selv[a2.5]. ||]E

238. S[[ι12.] n[ω7.] s[ι3.5]lêncio qu[ι7.5] s[ι3.] segu[ι1.], ||

239. ouv[ι3.]-s[ι1.] [a6.] minhoc[a7.5] pr[ι8.5]sioneir[a3.5]

s[ω3.]sp[ι6.5]r[a12.]r: |||

240. - [ω22.5]ff! ||

241. Qu[ι29.] [a9.5]l[ι19.5]vio! ||

242. Et[a.0] [ι6.]sp[a11.5]rt[ι13.]lh[ω.0] [a10.5]pert[a24.5]d[ω2.]! ||]E

243. S[[ι9.] v[ι9.]rand[ω2.]-s[ι3.5] p[a11.]r[a.0] [ω5.] M[a9.5]c[a19.]c[ω1.]: ||

244. - P[ω7.]r f[a7.5]vor, ||

245. l[a12.5]v[ι5.] minh[a4.5] c[a8.5]beç[a2.5] com [a12.]gua d[ι9.] coc[ω2.5],

sim? |||]E (Here, the speaker turns the page)

246. S[[ω6.] M[a10.5]c[a16.5]c[ω15.5] olh[a6.5] p[a11.5]r[a.0] [a9.]

Onç[a7.5]. ||]E

247. S[Est[a6.] faz um sinal d[ι6.] conten... sent[ι10.5]ment[ω3.5]. ||]E

248. S[[a4.5] m[ɩ8.5]d[ɩ11.]d[a.0] em qu[ɩ10.5] [a9.] [a16.5]gua vai [ɩ5.5]scorrend[ω2.] pel[a5.5] pen[a5.] d[ɩ9.5] graún[a3.], ||

249. el[a10.] vai s[ɩ3.5] soltand[ω1.] || /

250. [ɩ5.5] deixand[ω.0] [a12.5] mostr[a.0] [a6.5] tr[ɩ10.]st[ɩ8.5] calv[ɩ9.]cie d[ɩ6.5] C[a19.]r[ω5.5]lin[a.5]. ||]E

251. Decepção p[a12.]r[a5.] [ω2.] g[a9.5]fanhot[ω2.] p[a10.]quer[a9.5]dor. ||

252. [ɩ2.]spant[ω1.] geral. ||

253. S[[a9.]pen[a7.5]s don[a8.] C[ω16.5]r[ω17.5]j[a.0] [a8.5]rr[ɩ8.5]sc[a.0] um coment[a17.]rio: ||

254. - T[a14.]v[a5.5] n[a10.5] c[a24.]r[a3.]! || /

255. Ess[a4.] minhoc[a9.] nunc[a9.5] m[ɩ.0] enganou.]E

Appendix 3. Broad phonetic transcription of the corpus

The broad phonetic transcription reflect some significant acoustic realities that may be not significant at the perceptual or articulatory levels. A more acoustically-based transcription is made because the patterns they reflect were systematic at the acoustic level. For example, the occurrence of glottal stops preceding vowels, especially the vowel [a], the aspiration or frication of stop consonants, the formant transition within fricative consonants when a following vowel is completely deleted, and so forth. The numbers on the left correspond to the numbers in the orthographic transcription.

1. ([tex.'''se.rɑ̸_le''.tʊ.rɤ̸_''dʰɪ: ||])

2. [ʊ_'''sõ.ŋʏ̸_dʰɪ_ka.rø.'''lĩ.nɑ̸ |||

3. ka.rʊ.''lĩ.n͡ã_mĩ.'''ŋɔ.k ||

4. 'tɛ̃ʳ_'doʳž_'''grã͡ dɤž.'''goš.tʊš_na_'''vɪ.d ||

5. sex_ka.''rɛ.kɑ̸ |

6. ɪ_nãʊ_'tex_sĩ.'''tʊ.rɑ̸ ||

7. kɤ.mʊ̸_'to.dõʒa.b̤

8. a_mĩ.ˈˈŋɔ.kǿ_koɩ.ˈˈta.dǿ ||

9. ˈˈɛ͡ʷ_bɩ.ˈˈšɩ.ŋǿ_da_ˈˈtɛ.ʊǿ_kɩ_nã͡ʷ_ˈtẽɩ_ˈˈna:ᵈ_dʰɩ_bɯ.ˈˈnɩ.tǿ ||

10. ˈŋa͡i.d͡ɩš.pe.sɩ.ˈˈaʷ_kʰɩ_ˈˈpɔ.sa_ša.ˈˈma:ɾᵃ_a.tɛ̃.ˈˈsãʷ_dʰɩ_aʷ.ˈˈgẽɩ ||

11. a_ka.ˈˈbe.sǿ ||

12. kõ.plɛ.ta.ˈmẽ.tʰɩ_ˈˈlɩ.zǿ ||

13. nãʷ_ˈtẽɩ_ˈˈɯ̃:_ˈsɔ_ˈˈfɩɯ_dʰɩ_ka.ˈˈbe.lǿ ||

14. ɯ_ˈˈkoˣ.p͡ɛ_a.ˈkɛ.la_ˈˈkoɩ.za_ˈto.d͡ɩ.ˈˈgʷaʷ ||

15. sẽɩ_ɯ̃:_ˈˈɯ.nɩ.kɯ_sɩ.ˈˈnaʷ_dɯ_kɩ_sɩ_po.de.ˈˈɾɩᵃ_ša.ˈˈmaʊ_

dʰɩ_sĩ.ˈˈtɯ.ɾǿ |||

16. a.ˈˈsĩ_ɛ_ka.ɾɯ.ˈˈlĩ.nǿ |||

17. ɩ:_pɯˣ_ˈseɾ͡a.ˈˈsĩ ||

18. mɯ̃ɩ.t͡ĩ.fe.ˈˈlɩ:sɩ_kõ.sɩ.ˈˈdɛ.ɾa |

19. kõ.plɛ.ta.ˈˈmẽ.tʰ_dɩš.pɾo.te.ˈˈžɩ.dǿ_pe.la_na.tɯ.ˈˈɾe.zǿ ||

20. swš.ˈˈpɩ.rĩ.ve.ˈˈžɔ:zɑ_kʷã.dω_ˈve_ω̃_ˈˈpa.sɑ.rʷ͡ɛ.zɩ.ˈˈbĩ.dø_

swa_plω.ˈˈma:.ž ||

21. o:_kʷã.d͡ø.bɩ.sɛʁ.vω̃š.xe.kɛ.brøš_fa.ce:.røž_da_

fωʁ.mɩ.gɑ ||

22. ˈˈdõ.na_da_sĩ.tω.ˈˈrĩ.ŋɑ_ˈmaɩž_ˈˈfĩ.na_dω_ˈˈʙeɩ.nø_dɑ_

bɩ.ša.ˈˈra.dɑ || 23. a: ||

24. ˈkɛ̃ɩ_mɩ_ˈˈdɛ.ra_ˈteˣ_ka.ˈˈbe.lωs ||

25. ˈkɛ̃ɩ_mɩ_ˈdɛ.ra_se_ˈdõ.n_dʰɩ͡_ω̃.ma_ˈˈlĩ.da.sĩ.ˈˈtω.ra |||

26. ɩ_pωx_sɩ_sĩ.ˈˈtʰɩx |

27. ˈˈtãω_ĩ.sa.tʰɩš.ˈˈfeɩ.ta_kõ͡_a_ˈˈprɔ.pɩɑ_fɩ.ˈˈgω:.rɑ |

28. kõ͡ a_ˈˈfɔʁ.mɑ_kɩ_ˈˈdeωʒ_λɩ_ˈˈdeω ||

29. ka.rω.ˈlĩ.nɑ_ˈvɩ.vɩ_ˈsɛ̃.pɩ_ˈˈmω̃ɩ.tø_ˈtrɩš.tʰɩ ||

30. kʷã.dø_ˈa_ˈˈfɛš.tɑ ||

31. ˈda_ˈsẽ.pɾɪ̸_ω̃_"ˈžeᶥ.tω_dʰɪ_"nãʷ_kõ.pa.ɾe."se̸ɾ̸ ||

32. dʰɪ."ˈzẽ.d͡ɪš.ta:ɾ̸_"ˈmω̃ᶥ.t͡a.ta.ɾe."ˈfa.da̸ |

33. a̸.laɾ̸."ˈgã.dʊ̸_sʊ̸a̸_"ˈtɔ.ka || 34. o:_ĩ."tãʷ ||

35. ĩ."ˈvẽ.ta_kʰɪ_"ˈtẽᶥ_ω̃.ma_te."ʁɪ.vɛʷ_"ˈdoɾ̸_dʰɪ_peš."ˈko.s̃ ||

36. ω_ma."ˈka:_ka."ˈsoᵃ ||

37. ˈkʰɪ_peš."ˈko.sʊ̸_ka.ɾω."ˈlĩ.na |

38. ka."ˈde_seɾ̸_peš."ˈko.sʊ̸

39. vo.ˈse_ɛ_ˈto.da_"ˈtãʷ_ɪ.gʷaʷ."ˈzĩ.ŋa̸_kʰɪ_nẽᶥ"_ɪ.sω_"ˈtẽᶥ |

40. maᶥš_pa."ˈɾɛ.sɪ̸͡_ω̃_ka.nω."ˈdĩ.ŋʊ̸_dʰɪ_ʁe."ˈfɾeš.kʊ̸ ||

41. ka.ɾω."ˈlĩ.n͡a.mω."ˈa.da̸ ||

42. ĩ."ˈtɛ.ʁa_sɪ̸͡a.ˈĩ.da̸_"ˈmaᶥz͡ẽᶥ_sʊ̸a̸_"ˈtɔ.ka̸_na_"ˈtɛ.ʁa |

43. tẽᶥ.ˈmã.dʊ̸_ẽᶥ_nãʷ_ˈɪɾ͡a_ˈpaɾ̸.tʰɪ͡aʷ.ˈgω̃.ma̸ ||

44. a_"ˈka.da̸_"ˈdʰɪᵃ_kʰɪ."ˈpa.sa̸ ||

45. aʷ.ˈˈmɛ̃.t͡ ɯ_ˈˈse͡ ɯ.ˈˈmox ||

46. ˈˈsɛ̃.pɐ_sɔ.ˈˈzĩ.ŋə

47. ˈˈtɔx.na_sɐ_ˈka.da_ˈˈveɪʒ_maɪʒ_ʋeʒ.mɯ̃.ˈˈgõ.n͡ ɪ͡ s.kʰɪ.ˈˈzɪ.tʔ||

48. ˈˈsɛx.tʊ_ˈˈdʰɪa ||

49. ˈˈpa.sə_pɯr͡ ˈˈɛ.l͡ a_ta.tɯ.ˈˈrã:.nə ||

50. ɪ_a.ˈˈʋɪs.kᵃ͡ ɯ̃_kɯ̃.prɪ.ˈˈmɛ̃.tʊ ||

51. ˈbõ_ˈˈdʰɪ:ᵃ_ ka.rɯ.ˈˈlɪ.nə ||

52. ˈbõ_ˈˈdʰɪa_koɪ.ˈˈzɪ.sɪ.mə_nĩ.ˈˈŋɯ̃.mə_ʋes.ˈˈpõ.dʰɪ͡ a_mĩ.ˈˈŋɔ.kʔ_

kõ_ˈˈmaʷɪ_ˈˈmɔ.dʊs ||

53. maɪ͡ ɯ_kʰɪ͡ ɛ_ˈˈɪ:.sʊ_ka.rɯ.ˈˈlĩ.nə ||

54. ĩ.ˈˈtãʷ_nãʷ_ˈa_dʰɪ_seʋ_ˈˈbõ:_ɯ_ˈdʰɪa_kʰɪ_ˈdeʷɪ_nɯz_

ˈˈmã:.da_ˈse.ɯ_dʰɪ_ka.ˈˈlox ||

55. kõ_ɯ_ˈˈsɔʷ_brɪ.ˈʎã.dʊ_na_ˈˈma.ta ||

56. 'õ.dʰɪ̸_po."'dẽ.mωɪ̸_ʁeɪ̸.pɪ."'raɪ̸ ɪ_vɪ."'veɪ̸ ɛ̃ɪ_lɪ.beɪ̸."'da.dʰɪ̸ ||

57. "'ɪ.sω_'dʰɪz_vo."se ||

58. "'sɔ_pωɪ̸.ke |

59. ɛ_pe.lω."'dʰɪ.sɪ.ma_kõ.mʷ"'ɛ ||

60. sɪ_'fo.sɪ̸_"'lɪ.z ɪ_ka."'rɛ.kɪ̸_kõ.mɪ̸_"'eʷ |

61. kɪ.'rɪᵃ_"'veɪ̸_kõ.mʷ ɪ̸."'rɪᵃ_sɪ̸_sɪ̃."'tʰɪ ||

62. maɪ̸_nãʷ_'ve.zω_ʁa."'zãʷ_pra_'tã.tω_dʰɪ.zɪš."'pe.rω ||

63. a_taɪ̸.ta."'rω.g ɛ_ka."'rɛ:._kõ.mɪ̸_vo."'se |

64. a."'lɛ̃ɪ_dʰɪ_"'seɪ̸_kaš."'kω.dɪ̸ ||

65. ɪ_'vɪ.vɪ_"'to.da_fe."'lɪš_pa.ke."'rã.d ω_ža.bω."'tʰɪ |||

66. "'bɔ:.laš_pra_vo."'se_pra_taɪ̸.ta."'rω.g_ɪ_a."'tɛ_prω_ža.bω."'tʰɪ |||

67. "'dʰɪ.t ω_dʰɪ.za."'fo.rω

68. ka.rω."'lɪ̃.na_'saɪ_"'tãʷ_a.pre."'sa.dɪ̸_kʰɪ_"'da_ω ɪ̃.kõ."'trãʷ_

69. kʰɩ_''da_ῶ ĩ.kõ.''trãʷ_nω_la.''ga:ɣ.tø_kʰɩ_'vaɩ_

pa.'sã.d͡a.bra.''sa.dø_kõ_'swᵃ_na.mo.''ra.da |

70. a_''kɔ.brɤ ||

71. ''ɔ:ra_''ve.ža_''sɔ ||

72. ʙez.''mῶ:.gɤ ||

73. nãʷ_''seɩ_ω_kʰɩ͡ω_la.''gaɣ.tω͡a.ša_'nɛ.sa_''kɔ.br ||

74. ka.''rɛ:.k͡ɩ_sɛ̃ɩ_sĩ.''tω.ra_kõ.ɱʷ͡ẽω ||

75. ''dõ:.na_kω.''rω.žɤ ||

76. meɩ.ø_kω.šɩ.''lã.dω_so.ʙɤɩ͡ῶ_''trõ.kω_dʰɩ_''a:ʙ.vɤ ||

77. ''a.bɤɩ͡ωz͡ɔ̃.lɩω͡so.no.''lɛ̃.tøz͡ɤ_ko.''mɛ̃.tɤ ||

78. kɛ̃ɩ_'am͡ω_''feɩ.ø_bω.''nɩ.tω_λɩ_pa.''rɛ.s̃ʔ ||

79. ''ža_''vɛ̃ɩ_a_sĩ.''ŋɔ.ra_kõ_seʷ͡seʙ.''mõɩš ||

80. ''ɔ:ra_''va_dωʙ.''mɩ:

81. sω:ᵃ_'ɔ.ra_dʰ͡a.koʙ.''da:_nãʷ_ɛ_a_''noɩ.tʰɤ ||

82. kõ.″fɔ:ɸ.mɩ_sɤ_kõ_kɩ_′dewš_ʎɩ_″de:°_ka.rø.″lĩ.na |

83. po.de.″rɩa_sex_″pɩɔx ‖ 84. ″pɩ:ɔx ‖

85. ′ɛ_dʰɩ.″maɩš ‖

86. ɩš.″plɔ.dʰa_mĩ.″ŋɔ.ka_zɩ.gɩ.za.gɩã: dʰɩ_″xaɩv ‖

87. kõ_″ɛsa ‖

88. ″vɔ:ʷ.tw_pra_′ba:.š_da_″tɛ.ʁa_dʰɤ_′õ.dʰɩ_″n:ω̃.ka_

de.ve.″rɩa_′tex_″šaɩ.dɤ |

89. ″pa.sɤ_′mω̃ɩ.tω_″bɛ̃ɩ |||

90. ″lĩ.da_′taʁ.dʰɩ_dʰɩ_″sɔω ‖

91. ″sɛ:_ka.rω.″lĩ.na | 92. ″kõ.mω_sɛ̃.prʔ_″trɩš.tʰɩ ‖

93. ″pe.lɩš.″tra.da_″kɩ_″lɛ.va_swa_″tɔ.ka |

94. ″vaɩ_dʰɤ_ka.″be.sa_″ba:ɩ.ša_pẽ.sa.″tʰɤ.va ‖

95. ɛ_″kʷã:_″da_kõ_wz.ɔ.lɩωz_nω.ma_″pɛ.na_dʰɩ_gra.″ω.na |

96. ka.ˈɪ.da_nɯ_ˈšã̃ʷ ‖

97. ˈna.sɤ_ɯ̃.ma_lɯ.mɪ.ˈnɔ.zɪ.ˈdɛ.ɪ ‖

98. a.ˈtɛ.kɪ.ˈfĩ: ‖

99. pa.ˈrɛ.sʔ_kɪa.ˈka.bɯ_dʰɤ_ĩ.kõ.ˈtrara_pɪ.ˈrɯ.ka_
dʰɤ_kʰɪ_ˈtã.tɯ_pre.sɪ.ˈza.va ‖

100. ˈpre:.ta_se.ˈdɔ:.za_ˈlĩ.da |

101. a.ˈdeʷš_ka.ˈrɛ.kʰ ‖

102. ˈlɛ.va_ˈpɛ.na_pa.ra_ˈka.za ‖

103. ɪ_a_trãš.ˈfɔʙ.ma_nɯ.ma_pe.ˈrɯ.ka_dʰɪ_ˈfrã.ža ‖

104. kõ_ˈɪ.s ‖ 105. ˈfɪ.ka_ˈsɔ_faʷ.ˈtã.dɯ̃.ma_ˈkoɪ.z |

106. a_sĩ.ˈtɯ:.ra ‖

107. ˈkõ.mɯ_kõ.sɪ.ˈgɪra.fɪ.ˈna_la ‖

108. ˈtã.tɯ_pẽ.ˈsoʷ ‖

109. kχ͡a.ka.ʺ'boʷ_pωr_sι_lɛ̃.ʺ'braʙ_dʰχ_kι_ʺ'tĩ.ŋa_ʺ'vιš.t͡a_
fωʙ.ʺ'mι.ga_žo.ʺga_nω_ʺ'lι.s̃: |

110. ʺω̃_dʔʼšeʷ_šɛ.le.brχz͡χš.pax.ʺ'tι.λʔɣ ||

111. ʺ'pɛ_ã.tʰι_ʺ'pɛ ||

112. 'vaʼχ͡.'ka.za_da_fωʙ.mι.ʺ'gĩ.ŋ ||

113. ĩ.ʺ'kõ.tr͡a.'la.ta_dʰχ_ʺ'lι.s̃ ||

114. 'vι.ra_ʺ'ka || 115. 'vι.ra_dʰι_ʺ'la ||

116. χ͡a.'ka.b͡ĩ.kõ.ʺ'trã.dʔ || 117. a.ʺ'tɛ_k͡ι.ʺ'fĩ ||

118. ω_se.ʺ'gre.dω_dʰχ͡ω̃.ma.ʺ'lĩ.da_sĩ.tω.ʺ'rĩ.ŋa ||

119. ʔš.ta_'mω̃ʼ.tʔ_ʺ've.λ̃ |

120. ma͡sa.be.ʺ'reʼ_'kõ.mω.'dar͡ω̃_ʺ'žeʼ.tʔ |||

121. ɛ̃_ʺ'ka.sχ

122. kõ.ʺ'sɛx.tχ͡ιš.pax.ʺ'tι.λ͡a.'tɛ_fι.'kar͡ɛ̃ʼ_kʔ.dʰι.ʺ'sõʼχ_dʰχ_

ˈser͡ω̃.ˈˈza.dø ||

123. ˈˈpõɪ_sɪ_dʰɪ.ˈã.tʰ_dʰ͡ω̃_ˈˈka.kˀ_dʰ͡χš.ˈˈpe.λ ||

124. ɪ_ˈˈvaɪ_kõ.ˈˈpõ.d͡a_fɪ.ˈˈgω.ra_dʰ_ω̃.ma_ˈˈnɔ.va_ka.rω̃.lɪ.n ||

125. a_pe.ˈˈrω.k͡a.ˈˈsĩ_grω̃.ˈˈda.da_kõ_ˈˈkɔ.la.ˈˈtω.d͡š.ta_ˈˈmež.mω_

ba.ˈˈka.na ||

126. ˈš.to:_a.ˈˈtɛ_pa.re.ˈˈsɪ.da_kõ_a_ˈtaʷ_kle.ˈˈɔ.pa.tra_

xa.ˈˈĩ.ŋa_dω_e.ˈˈžɪ.tø ||

127. ɪ_a_sĩ.ˈˈtω.ra || 128. ˈˈω:f: ||

129. ˈˈkõ.m͡χš.ˈˈta_a.peʁ.ˈˈta:.dˀ ||

130. ˈˈna.da_kõ.m͡ω̃_χš.pax.ˈˈtɪ.λˀ |

131. ˈˈbẽɪ_kɪ_ˈˈva.l͡ɪω_sa.krɪ.ˈˈfɪ.š ||

132. sa.tɪs.ˈˈfeɪ.ta_kõ_a_ˈˈnɔ.va.pa.ˈˈrɛ̃.š ||

133. ˈˈpa.s͡aʷz.ˈˈωl.tɪ.mωz_a.ˈʁã.ž ||

134. "ɔ.kω.lωz͡iš."kω.rɸš ||

135. sa."pa.tʰ_dʰι_"saʷ.tωz͡"aʷ.tʔš |

136. sõ."brĩ.ŋa_veʁ."me:λa_a."bεx.tʔ ||

137. fe."lιš || 138. 'la_"vaι_pe.l͡ιš."tra.d͡ĩ.so.la."ra.dʔ ||

139. aʷ_pa."ša_pe.lo_ga.fã."ŋo.tω_xe."sε.b͡ιω_

pri."me:.rɸ_e.lo."gι:_dʰ͡a.pro.va."šãʷ ||

140. "o: ba_koι."zĩ.ŋa_"fo.fʔ || 141. vaι."dɔ.za ||

142. ka.ro."lĩ.na_"fɔx.s͡ω̃_xε."kε:.br͡χ_kõ.tʰι."nωᵃ_

žĩ."gã.dω_pe.lɸ_ka."mĩ.ŋɸ ||

143. "dõ.na_kω."rω.ž ||

144. kʰχ͡a_"tω.d͡o.bχ."sεʁ.ya_dʰʔ_šeω_"poš.t͡a.vã."sa.dω_

ko."mẽ.ta ||

145. tʰι.'rã.dʰ_sʷaš_kaš."kĩ.ŋaz͡"ε̃ι_ga.fa."ŋo.tʔ ||

146. "a:_'dõ.na_kω."rω.žʔ ||

147. a_sĩ.ˈŋɔ.r͡ʏš.ˈˈta.v͡ʌ̃ˈɩ ||

148. ɩš.ˈˈta:.va_ɩ_ɩš.ˈˈtoʷ ||

149. ɛ.l͡a.ˈˈtɛ_kʰ͡ʏ ɛ_ba.ˈˈkã.na_nãʷ_ˈˈa.ša ||

150. ˈˈɛ:.la:_ˈˈkẽɩ ||| 151. ɛ:.la:_ɛ:.la:_ˈseɩ_ˈˈla: ||

152. ˈˈkʰẽɩ_ɛ_ˈˈɛ.l͡a.fɩ.ˈˈnaʷ || 153. nãʷ_ˈˈseɩ |

154. vo.ce_ˈˈsa.bɩ | 155. tã.ˈbẽɩ_ˈˈnãʷ ||

156. ɛ_e.ˈˈzɔ.tʏ.ka_dɩ.fe.ˈˈrẽ.tʰ ||

157. ˈˈnãʷ_sʏ_pa.ˈˈrɛ.s̃_kõ_nĩ.ˈˈŋw̃_dwž_ˈˈbɩ.šʏʏ_dw_ˈˈʙeɩ.nˀ||

158. ˈˈoʷ_se.ˈˈra_kɩ_pa.ˈˈrɛ.sʏ ||

159. ˈˈnãʷ_ˈseɩ_ˈˈbẽɩ || 160. w̃: ||

161. ˈˈɩ.s̃_ˈda_ˈˈmw̃ɩ.tʰ_nw_kʰɩ_pẽ.ˈˈsax ||

162. se.ˈˈrɩᵃ_ka.ˈˈpaɩz_dʰ_žw.ˈˈraʏ_kɩ_ˈža_ˈˈvɩ_ˈɛ.sa_

ˈˈkoɩ.sa_ˈˈã.tʰš ||

163. se.ʺra_kẽĩ ̆s.ʺtoʷ_pẽ.ʺsã.dʔ ||

164. maʲš_tʰa.ʺmẽĩ_ʹpɔ.dʰ_ʺsex_kɩ_nãʷ_ʺse.žd ||

165. ω̃:_ʺseɩ_ʺnãʷ ||| 166. ʺdʰeɩ.ša_pra_ʺla |

167. ʺkʰɛ͡sa.ʺbe ||

168. pωrʺω̃.ma_keš.ʺtãʷ_dʰɣ_kaʷ.ʺtɛ.la ||

169. ʺa.šω_me.ʺʎɔr_le.ʹvar͡ω_ʺka:.z͡ãʷ_kõ.ŋe.sɩ.ʺmẽ.tʰω_

dʰɣ_ʹnɔ.sa_xa.ʺĩ.ŋa | 170. a_ʺõ.sd

171. ʺsẽ.prɩ_xa.šʲo.sɩ.ʺnã.dω_kʰõ_sa.bɩ.dω.ʺrɩᵃ_ʹdõ.na_

kω.ʺrω.ža ||

172. nãʷ_ɛ_a_ʺtoᵃ_kʰɣ͡a_bɩ.ša.ʺra.da_ʺto.da_ʹgɔš.tʰa_

dʰoʷ.ʺvɩx_sewš_kõ.ʺse.ʎš ||

173. ʺva.mωž_dɩ.ʺprɛ.sa_fa.ʺla͡ra_ʙa.ʺĩ.ŋa ||

174. ɩ_ʺbẽĩ_dʰɩ.ʺprɛ.sa_ʺvãʷ |||

175. ι_xo.ˈˈgã.mwẑa_ˈˈvɔ.sa_ma.žeš.ˈˈta.dʰι ||

176. ˈˈtõ.mι_pro.vι.ˈˈdε̃.sιaẑa_ˈˈfĩ_dʰι_pro.te.ˈˈze_
ˈnɔ.syš_fι.ˈˈλɔ.tʰιs ||

177. kõ.trε̂.sa_koι.zχš.ˈˈtrã.ηa_kι_ʔ.ˈˈkʰa.ba_
dʰa.pa.re.ˈˈsefε̃ι_sewž_do.ˈˈmĩ.nιwš |

178. ˈˈtε̃.ηw_ˈˈdʰι.tʔ ||

179. dʰι.ˈˈbaι.šw_dʰχω̃.ma_ˈˈsaw.va_dʰι_ˈˈpaw.maž_da_
bι.ša.ˈˈra.dʰ ||

180. ˈdõ.na_kw.ˈrw.ža.ˈˈka.ba_sew_dιš.ˈˈkwx.sy_
dʰι.rι.ˈˈžι.da.ʁa.ˈˈĩ.ηa ||

181. ĩ_de.ˈˈfe.za_dyĩ.te.ˈˈre.sχ_dʰχ_ˈˈto.dyš ||

182. ˈˈkʰõ.tε̃ι_kõ.ˈˈmι.gw || 183. ˈˈxw.žιa_ˈˈõ.sʰ ||

184. ˈˈkʔõ.tε̃ι_kõ.ˈˈmι.gw ||

185. "nã^w_de.se.pɤ.sˡo.na."re^ɩ_me^w"sω.d^hɩ.twʒ ‖

186. "bra:.vω:_"vɩ.va_"õ.s̃a:_"vɩ.va: ‖

187. a."pla^υ.s̃ɸɸ_d^hɩ_"to.dɸz͡ωš."k^hã.t^ʔš ‖

188. a.pro.va."sõɩ z͡ɛ̃ɩ_"to.daz͡ až_"bo.k^ʔš ‖

189. "ma:ˡš ‖ 190. ɛ̃ɩ_"to.dař_"me:ž.mɩ ‖

191. "bɛ̃ɩ: | 192. ɛ̃ɩ_"k^hωa.zɩ_"to.dɤš ‖

193. "fa^ω.t^ha_"s̃ɔ_a_d^hɩ_ka.rω."lĩ.na ‖

194. "ɛ_k^hɤ͡ɛ:.la_kõ.plɛ.ta."mɛ̃.t^h_pωx_"fɔ.ra_

dωz͡a.kõ.te.s̃."mɛ̃.t^ʔš ‖

195. ɤš."ta_ɤ.d^hɤ.mɩ."rã.dω_"sɤa_"nɔ.va_fɩ."gω.ra_

ʁe.fle."t^hɩ.da_naz͡a.g^ωaɤ_dω_"la:.g^ʔ ‖

196. "e:.t^h ɩš."pe.λ^ʔ_le."ga^ω ‖

197. to:_"lĩ.da_d^hɤ."ma:ˡš ‖|

198. ĩ.ˈˈkʷã.tʰω_ˈˈι:ɜ̃ ||

199. ωz͡a.nι.ˈˈmaιš_ˈˈtra.sãʷ_ˈˈpla.nωš_dʰι_de.ˈˈfe.za_
kɤ.tra͡ɣš.ˈˈtrã.ŋ͡ĩ.va.ˈˈz̃o.ra |||

200. o.kω.ˈˈpã.dω_ˈkʰa.da_ˈkʰʷaʷ_ω_seʷ_ɣš.kɤ.dι.ˈˈrι.ž̃ |

201. ˈfι.kãʷ_ɣš.pe.ˈˈrã.dø͡a.pa.re.sι.ˈˈmɛ̃.tø_da_ˈˈfɛ.rə ||

202/203. a_mĩ.ˈˈŋɔ.kʰ ||

204. ɤ̌.trã.ˈˈŋã:.d_ˈˈtã.tω_sι.ˈˈlɛ̃.ɜ̃ʰ |

205. ι_pe.la_prι.ˈˈmeι.ra_ˈˈveιš ||

206. de.ze.ˈˈžã.d͡ĩ.kõ.ˈˈtra͡raʷ.ˈˈgω̃_ˈˈbι.š͡øĩ_seʷ_ka.ˈˈmĩ.ŋˀ ||

207. ˈvaι_sι.ˈˈgĩ.dˀ_pe.l͡ ιš.ˈˈtra.da_prĩ.sι.paʷ ||

208. ˈˈkla.rø | 209. sɛ̃ιš.kʰe.ˈse͡rω_xe.bo.ˈˈla.dˀ ||

210. ι_ˈˈsɛ̃.prι_dʰι_ɜ̃ɤ.ˈˈbrĩ.ŋ͡a.ˈˈbɛx.tˀ ||

211. s:ι.ˈˈlɛ̃.sɣᴷ || 212. ˈla_ˈvɛ̃ι_a_ˈˈkoι.za_a.ˈˈvι.za_

"ˈdõ.na_kω"ˈrω.ž || 213. "ˈdeˑ.šĩ_pra_"ˈmĩ |

214. oʁ"ˈdẽ.nɑ_a_"ˈõ.s' || 215. ι_"ˈtra.ta_dʰι_ˈpox_"ˈga.ʁaz͡a_"ˈɔ.brˀ |||

216. ω̃.ma_"ˈxe.dʰι_te"ˈsι.da_kõ_"ˈfιʷž_dʰι_ˈteɪɑ_dʰɣ_a"ˈrã.ŋ ||

217. ε_lã"ˈsa.d͡ẽι_"ˈsĩ.ma_dʰι_ka.rω"ˈlĩ.nɑ ||

218. a_ko"ˈta.da_dι.zιš.pe"ˈra.dɑ_ɣš.peʁ"ˈneˑa || 219. "ˈsɔʷ.tẽι_mι ||

220. "ˈdeˑ.šẽι_ˈdʰι.sɣ || 221. eʷ_"ˈsoʷ_a_mĩ"ˈŋɔ.ka.rω"ˈlĩ.na:_

"ˈɔ.λẽι_pra_"ˈmĩ || 222. nãʷ_ɣš"ˈtãʷ_mι_xe.kõ.ŋe"ˈsẽ.dω |||

223. "ˈtẽ.t͡a.ʁã"ˈkar͡a_pι"ˈrω.kɑ || 224. "ˈmω̃ˑ.tω_bẽι_ko"ˈla.da ||

224. "ˈtẽι.ma_ẽι_nãʷ_sa"ˈιx || 225. "ˈl:a:ʁ.gẽι_mι ||

226. "ˈsoʷ_ka.rω"ˈlĩ.na_nãʷ_ɣš.tãʷ_"ˈvẽ.dɣ ||

227. mĩ:"ˈtʰι:ra:_"ˈgrι.ta_ɣ_ma"ˈka.kˀ | 228. mĩ"ˈtʰι.ra_

"ˈme:ž.mɣ || 229. a_mĩ"ˈŋɔ.k͡ε_ka"ˈrε.ka |

230. ι_nãʷ_"ˈtẽι_sĩ"ˈtω.ra || 231. vo.se_ε_ka.bι"ˈlω.d͡ι_

a.sĩ.tω"ˈra.da_kõ.mω̃.ma͡ɣ"ˈsa |||

232. "ˈpoˑz͡ɣš"ˈpε.rɣ_"ˈsɔ_pra_"ˈveɣ || 233. ι_ĩ"ˈsιš.tʰ͡ɣa_mĩ"ˈŋɔ.ka ||

234. a.ʙã̋ˈkʰã.d͡a_ˈsaːⁱω_ιš.pax.ˈˈtʰι.λʔ ‖ 235. ˈˈω̃ |

236. ˈˈɔː_dʰχ_ιš.ˈˈpã.tʰø_χš | 237. e.ko.ˈˈoʷ_pe.la_ˈˈsɛʷ.vʰ ‖

238. ˈˈι_nω_sι.ˈˈlɛ̃.sʰ_kι_sι_ˈˈsɛ.gʔ ‖ 239. ˈˈoʷ.vχ_sⁱa͡_mĩ.ˈˈŋɔ.ka_
prι.sⁱo.ˈˈneⁱ.ra_swš.pι.ˈˈraχ ‖‖ 240. ˈˈωːfː ‖

241. ˈkʰιː_a.ˈˈlι.vιʷ ‖ 242. ˈˈeːt͡ʰιš.pax.ˈˈtʰι.λ͡a.pex.ˈˈta.dø ‖

243. ι_vι.ˈˈrã.dʔ_sι_ˈpa.r͡ω_ma.ˈˈka.kʔ ‖

244. ˈˈpø_fa.ˈˈvoː ‖ 245. ˈˈla.vι_ˈmĩ.ŋa_ka.ˈˈbe.sa_kõ_
ˈˈa.gʷa_dʰχ_ˈˈko.kø_ˈsĩː ‖‖ 246. ø_ma.ˈˈka.kω_ˈˈɔ.λa_
pa.r͡a_ˈˈõ.šχ ‖ 247. ˈˈɛš.ta_ˈˈfaⁱz͡ω̃_sι.ˈˈnaʷ_dʰ_kõ.tʰĩ_
sɛ̃.tʰι.ˈˈmɛ̃.tø ‖ 248. a_mι.ˈˈdʰι.d͡ɛ̃ⁱ_kʰι_a_ˈˈa.gʷa_
ˈvaⁱš.ko.ˈˈxɛ̃.dʔ_pe.la_ˈˈpɛ̃.na_dʰι_gra.ˈˈω.nχ ‖

249. ɛ.la_ˈˈvaⁱ_sχ_ʒoʷ.ˈˈtã.dʔ ‖ 250. ι_deⁱ.ˈˈšã.d͡a_ˈˈmɔš.tr͡a_
ˈˈtrιš.tʰχ_kaʷ.ˈˈvι.sι_dʰι_ka.rω.ˈˈlĩ.nʔ ‖ 251. de.se.pχ.ˈˈsãʷ_
pa.r͡ω_ga.fa.ˈˈŋo.tʔ_pa.kʰe.ra.ˈˈdo ‖ 252. χš.ˈpã.tʔ_že.ˈˈraʷ ‖

253/255. a.ˈˈpɛ.naš_ˈdõ.na_kω.ˈˈrω.ž͡a.ˈˈxιš.k͡ω̃_kõ.mɛ̃.ˈˈta.rø ‖
ˈˈta.va_na_ˈˈka.ra ‖ ˈχ.sa_mĩ.ˈˈŋɔ.ka_ˈˈnω̃.kʰa_mĩ.ga.ˈˈno]

Appendix 4. Data patterns and analysis of variance

A4.1.0. The distribution of the vowel [ɩ]: all positions.

```
Quartiles = 4.5, 10

Decimal point is at the colon

    2 : 00000000000000000055555555
    3 : 0000000000000555555555555555
    4 : 0000000000000055555555555555555555555555555
    5 : 00000000000000000000005555555555555555555555
    6 : 0000000005555555555555555555555555
    7 : 00000000000000555555555555555
    8 : 00000000000000005555555555555555555
    9 : 00000000000000005555555555555
   10 : 00000000000000000555555
   11 : 0000005555555555555
   12 : 000005555555
   13 : 0000555
   14 : 0005
   15 : 00555555
   16 : 000055
   17 : 000555
   18 : 0005
   19 : 05555
   20 : 0555

High: 22.0 22.0 22.5 23.5 23.5 23.5 24.0 24.0 25.5
      26.5 26.5 29.0 37.5
```

A4.1.1. The distribution of the vowel [ɩ]: stressed position.

```
Quantiles = 9, 19

Decimal point is 1 place to the right of the colon

   0 : 4
   0 : 566666677777888889999
   1 : 00000001111122333344
   1 : 555666667777888899999
   2 : 00022233344
   2 : 669
   3 :
   3 : 7
```

A4.1.2. The distribution of the vowel [ɩ]: non-stressed positions.

```
Quantiles = 4.5, 9

Decimal point is at the colon

     2 : 00000000000000000055555555
     3 : 0000000000000555555555555555
     4 : 000000000000055555555555555555555555555555
     5 : 0000000000000000000005555555555555555555555
     6 : 0000000005555555555555555555
     7 : 000000000000555555555555
     8 : 000000000000005555555555555555
     9 : 0000000000005555555555555
    10 : 0000000000000555
    11 : 00005555555555
    12 : 0000055555
    13 : 005
    14 : 00
    15 : 05555
    16 : 0
    17 : 55

High: 20.5 25.5
```

A4.1.3. The distribution of the vowel [ɩ]: pretonic (pr2) position.

```
Quantiles = 4.5, 9

Decimal point is at the colon

     2 : 00055
     3 : 0000055555
     4 : 005555555
     5 : 0000055555555
     6 : 0055555
     7 : 005
     8 : 0005555
     9 : 00555
    10 : 000
    11 : 000055
    12 : 0055
    13 :
    14 :
    15 :
    16 : 0

High: 25.5
```

A4.1.4. The distribution of the vowel [ɩ]: pretonic (pr1) position.

```
Quartiles = 4.5, 9

Decimal point is at the colon

    2 : 000000555
    3 : 0000555555
    4 : 000000055555555555
    5 : 000000000000555555
    6 : 00555555555
    7 : 00000005555555
    8 : 00000555555555
    9 : 0000555555
   10 : 00000055
   11 : 5555
   12 : 0555
   13 : 5
   14 : 0
   15 : 0555

High: 20.5
```

A4.1.5. The distribution of the vowel [ɩ]: postonic (post1) position.

```
Quartiles = 4, 9

Decimal point is at the colon

    2 : 00000005
    3 : 005
    4 : 00555
    5 : 00555
    6 : 0000555
    7 : 005
    8 : 00555
    9 : 000555
   10 : 00
   11 : 5
   12 : 0
   13 : 0
   14 : 0
   15 :
   16 :
   17 : 55
```

A4.1.6. The distribution of the vowel [ɩ]: others.

```
Quantiles = 4.5, 9

Decimal point is at the colon

    2 : 0055
    3 : 00555
    4 : 0055555555
    5 : 0055555
    6 : 055
    7 : 0555
    8 : 0000
    9 : 0005
   10 : 005
   11 : 555
   12 : 0
   13 : 0
   14 :
   15 : 5
```

A4.2.0. The distribution of the vowel [a]: all positions.

```
Quantiles = 6, 12

Decimal point is at the colon

 2 : 00000000005555555555
 3 : 0000000000000055555555555
 4 : 000000005555555555555555555555555555555
 5 : 000000000000000000000000000005555555555555555555555555555555555
 6 : 000000000000000000000000000055555555555555555555555555555555555555
 7 : 0000000000000000000000000000000555555555555555555555555555555555555555x
 8 : 00000000000000000000005555555555555555555555
 9 : 000000000000000000000000000055555555555555555555555555555555
10 : 000000000000000000000000555555555555555555555555
11 : 000000000000055555555555555
12 : 000000000000555555555555555
13 : 0000000000555555555555
14 : 00000000055555555555
15 : 000000000555555555555
16 : 000055555
17 : 00000055555
18 : 000555
19 : 00000555555
20 : 555555
21 : 00005
22 : 005555
23 : 005
24 : 00

High: 24.5 24.5 25.0 27.0 27.5 28.5 28.5 29.5 31.0 31.5 33.5 41.0 84.0
```

A4.2.1. The distribution of the vowel [a]: stressed position.

```
Quantiles = 12, 19.5

Decimal point is at the colon

 5 : 0
 6 :
 7 : 0
 8 : 055
 9 : 00555
10 : 000000555555
11 : 000055
12 : 0000055555
13 : 0000055555
14 : 000055555
15 : 0000000555555
16 : 00555
17 : 0000055
18 : 00055
19 : 000555555
20 : 555555
21 : 00005
22 : 00555
23 : 05
24 : 005
25 :
26 :
27 : 05
28 : 55
29 : 5
30 :
31 : 05

High:  41  84
```

A4.2.2. The distribution of the vowel [a]: non-stressed positions.

```
Quantiles = 5.5, 9.5

Decimal point is at the colon

   2 : 0000000000
   2 : 5555555555
   3 : 00000000000000
   3 : 55555555555
   4 : 00000000
   4 : 5555555555555555555555555555555
   5 : 0000000000000000000000000000
   5 : 55555555555555555555555555555555555
   6 : 0000000000000000000000000000
   6 : 555555555555555555555555555555555555555
   7 : 000000000000000000000000000000
   7 : 5555555555555555555555555555555555555555555555
   8 : 000000000000000000000
   8 : 555555555555555555555
   9 : 00000000000000000000000000
   9 : 555555555555555555555555555555
  10 : 0000000000000000
  10 : 555555555555555555555
  11 : 000000000
  11 : 555555555555
  12 : 0000000
  12 : 5555555555
  13 : 00000
  13 : 5555555
  14 : 00000
  14 : 555555
  15 : 0
  15 : 5555555
  16 : 00
  16 : 55
  17 : 0
  17 : 555

High: 18.5 19.0 19.0 22.5 23.0 24.5 25.0 33.5
```

A4.2.3. The distribution of the vowel [a]: pretonic (pr2) position.

```
Quantiles = 6.5, 10.5

Decimal point is at the colon

   2 : 05
   3 :
   4 : 555555
   5 : 00555
   6 : 000005555555
   7 : 00000555555555555
   8 : 0000555
   9 : 000055555
  10 : 00000555555
  11 : 05
  12 : 00555
  13 : 05
  14 : 000055
  15 : 05
  16 : 5
  17 : 0

High:  19  19
```

A4.2.4. The distribution of the vowel [a]: pretonic (pr1) position.

```
Quantiles = 7, 11

Decimal point is at the colon

    2 : 0
    3 : 55
    4 : 00555
    5 : 0000005555
    6 : 000055555555555
    7 : 00000000555555555
    8 : 00000055555555
    9 : 0000000000555555555555555
   10 : 000555555555555
   11 : 00000055555
   12 : 0005555
   13 : 0005555
   14 : 0555
   15 : 555
   16 : 05
   17 : 555
   18 : 5

High: 22.5 23.0 25.0
```

A4.2.5. The distribution of the vowel [a]: postonic (post1) position.

```
Quantiles = 4.5, 8

Decimal point is at the colon

    2 : 00000000555555555
    3 : 000000000000055555555
    4 : 000005555555555555555555
    5 : 0000000000000005555555555555555555555555
    6 : 000000000000000005555555555555555555
    7 : 0000000000000005555555555555555555555
    8 : 000000000000555555
    9 : 000000000055555555
   10 : 00000055
   11 : 055555
   12 : 0555
   13 : 05
   14 : 5

High: 15.5 24.5 33.5
```

A4.2.6. The distribution of the vowel [a]: others.

```
Quantiles = 5, 9.75

Decimal point is at the colon

 3 : 05
 4 : 0555
 5 : 00000555
 6 : 0055
 7 : 00055
 8 : 555
 9 : 0005
10 : 005
11 : 05
12 : 0
13 : 5
14 :
15 : 55
16 : 0
```

A4.3.0. The distribution of the vowel [ω]: all positions.

```
Quartiles = 4, 9.5

Decimal point is at the colon

 2 : 00000000000000000000055555555
 3 : 000000000000000555555555555555555
 4 : 0000000000005555555555555
 5 : 0000000000005555555555555555
 6 : 0000000000000555555555555
 7 : 00000000000055555555555555
 8 : 0000000000555555
 9 : 00000555555555
10 : 000055555555
11 : 0000000005555555
12 : 00005
13 : 0055
14 : 00005
15 : 055
16 : 055
17 : 000555
18 : 5
19 : 000
20 : 00

High: 21.0 22.0 22.5 24.5
```

A4.3.1. The distribution of the vowel [ω]: stressed position.

```
Quartiles = 11, 18.5

Decimal point is at the colon

 8 : 00
 9 : 55
10 : 0555
11 : 055
12 : 00
13 : 005
14 : 00
15 : 0
16 : 0
17 : 000555
18 : 5
19 : 000
20 : 0
21 : 0
22 : 05
23 :
24 : 5
```

A4.3.2. The distribution of the vowel [ω]: non-stressed positions.

```
Quartiles = 3.5, 8

Decimal point is at the colon

   2 : 00000000000000000000055555555
   3 : 000000000000000555555555555555555
   4 : 0000000000005555555555555
   5 : 0000000000005555555555555555
   6 : 0000000000000555555555555
   7 : 00000000000055555555555555
   8 : 00000000555555
   9 : 000005555555
  10 : 00055555
  11 : 0000000055555
  12 : 005
  13 : 5
  14 : 005
  15 : 55
  16 : 55

High:  20
```

A4.3.3. The distribution of the vowel [ω]: pretonic (pr2) position.

```
Quartiles = 4, 7

Decimal point is at the colon

  2 : 00
  3 : 000
  4 : 0055
  5 : 00
  6 : 0055
  7 : 00005
  8 :
  9 : 05
```

A4.3.4. The distribution of the vowel [ω]: pretonic (pr1) position.

```
Quantiles = 6.5, 11

Decimal point is at the colon

  2 : 5
  3 : 00
  4 : 005555
  5 : 0055
  6 : 0000555
  7 : 000000555555
  8 : 000055
  9 : 0005555
 10 : 005555
 11 : 0000005555
 12 : 005
 13 :
 14 : 05
 15 : 5
 16 : 55
```

A4.3.5. The distribution of the vowel [ω]: postonic (post1) position.

```
Quantiles = 3, 6

Decimal point is at the colon

  2 : 0000000000000000005555555
  3 : 00000000055555555555555
  4 : 0000000555
  5 : 00000555555555555
  6 : 000005555
  7 : 055555
  8 : 0005555
  9 : 05
 10 : 5
 11 : 00

High: 13.5 14.0 15.5 20.0
```

A4.3.6. The distribution of the vowel [ω]: others.

```
Quantiles = 4.25, 6.75

Decimal point is at the colon

 2 : 0
 3 : 05555
 4 : 05555
 5 : 00055
 6 : 00555
 7 : 055
 8 : 0
 9 : 5
10 : 0
11 : 5
```

A5. The analysis of variance of the four word positions: pr2, prl, stressed and post1.[10]

The vowel [ι]

```
1BMD06VA -- UCLA 1965  (UT PSYCHOLOGY VERSION   1 AUG 1978)
0PROBLEM CODE:  SAMPLE      BY SQBY514   21 APR 87 13.02.36.
0 2 INDEPENDENT VARIABLES AND   1 DEPENDENT VARIABLES(  1 TYPE-I  1 TYPE-II)
   FORMAT CARDS WITH 10 ITEMS PER CARD.
0OPTIONS IN EFFECT
 F - TESTS,S UNEQUAL,

0INDEX                  G    S
 NUMBER OF LEVELS       4   127
 POPULATION SIZE      CC4   INF
0DESIGN CARD         GS        G,S(G),*G.
0VARIABLE FORMAT        (10(F4.1,3X))

0                  GROUP CONTROL CARDS

 GROUP  1 SIZE   74
 GROUP  2 SIZE  127
 GROUP  3 SIZE   78
 GROUP  4 SIZE   50
0UNWEIGHTED MEANS SOLUTION FOR VARIABLE S WITH  329 INSTANCES.

CORRECTION RATIO .58102196
1ANALYSIS OF VARIANCE FOR TYPE-I VARIABLE   1 AND TYPE-II VARIABLE   1
0     SOURCE            SUM OF          DF      MEAN          F-TEST  P(F)  ERROR
                        SQUARES                 SQUARE                      TERM

    1  MEAN            22834.3           1   22834.3        1137.96  .000  S(G)
    2  G               3145.46           3   1048.49          52.25  .000  S(G)
    3  S(G)            6521.47         325   20.0661
0GRAND MEAN
0       8.7956052
0CELL MEANS
0    G =          1              2              3              4
             6.8919         7.0118         14.449         6.8300

2DATA FOR PROBLEM SAMPLE RUN BY SQBY514     21 APR 87 13.02.36.
1NEWMAN-KEULS TEST FOR ORDERED MEANS
                              DATA RUN  21 APR 87
```

[10] As it was discussed in chapters 4 and 5, no significant difference appeared in the analysis of variance when pr2 and prl were paired. This is due to pairing these two positions without taking into consideration syllables starting with consonant and syllables starting on a vowel. When these two types of pr2 syllables were categorized in two sub-groups their medians were largely different as the rules proposed in Chapter 5 show.

The vowel [ɩ]

PROBLEM NAME - PFDURI1
NUMBER OF MEANS 4
OBSERVATIONS PER MEAN (AVG) 73.000000
DEGREES OF FREEDOM FOR ERROR TERM 288
ERROR TERM 20.066000

TREATMENTS

ORDER	TREATMENT NR	MEAN
1	3	14.449000
2	2	7.0118000
3	1	6.8919000
4	4	6.6300000

TABLE OF Q-STATISTICS

VALUES FOR ROW 1

COLUMN	MEAN	VS MEAN	R	DF	Q	.05	.01	VALUE
4	3	4	4	288	14.5321	3.69	4.50	**
3	3	1	3	288	14.4141	3.36	4.20	**
2	3	2	2	288	14.1854	2.80	3.70	**

VALUES FOR ROW 2

COLUMN	MEAN	VS MEAN	R	DF	Q	.05	.01	VALUE
4	2	4	3	288	.346757	3.35	4.20	NOT-SIGN
3	2	1	2	288	.228692	2.80	3.70	NOT-SIGN

VALUES FOR ROW 3

COLUMN	MEAN	VS MEAN	R	DF	Q	.05	.01	VALUE
4	1	4	2	288	.118065	2.80	3.70	NOT-SIGN

The vowel [a]

```
1BMJ08VA -- UCLA 1965  (UT PSYCHOLOGY VERSION   1 AUG 1978)
0PROBLEM CODE:  SAMPLE      BY SGBY514    21 APR 87 12.42.02.
0 2 INDEPENDENT VARIABLES AND   1 DEPENDENT VARIABLES(  1 TYPE-I  1 TYPE-II)
    FORMAT CARDS WITH 10 ITEMS PER CARD.
0OPTIONS IN EFFECT
 F - TESTS,S UNEQUAL,

0INDEX                  G     S
 NUMBER OF LEVELS       4   235
 POPULATION SIZE      C04   INF
0DESIGN CARD         GS         G,S(G),$G.
0VARIABLE FORMAT         (1C(F4.1,3X))

0               GROUP CONTROL CARDS

 GROUP   1 SIZE    9C
 GROUP   2 SIZE   145
 GROUP   3 SIZE   126
 GROUP   4 SIZE   235
0UNWEIGHTED MEANS SOLUTION FOR VARIABLE S WITH  596 INSTANCES.

CORRECTION RATIO .56362795
1ANALYSIS OF VARIANCE FOR TYPE-I VARIABLE   1 AND TYPE-II VARIABLE   1
0      SOURCE            SUM OF          DF      MEAN          F-TEST  P(F)  ERROR
                         SQUARES                 SQUARE                      TERM

    1  MEAN              58C87.0          1     58087.0      2379.85 0.000  S(G)
    2  G                 76C0.55          3     2533.52       103.80 0.000  S(G)
    3  S(G)              14449.4        592     24.4078
0GRAND MEAN
0       10.470786
0CELL MEANS
0     G =         1                2               3               4
             9.00C0          9.5621          1E.738          6.5830

2DATA FOR PROBLEM SAMPLE RUN BY SQBY514    21 APR 87 12.42.02.
1NEWMAN-KEULS TEST FOR ORDERED MEANS
                              DATA RUN  21 APR 87
```

The vowel [a]

PROBLEM NAME - SAMPLE
NUMBER OF MEANS 4
OBSERVATIONS PER MEAN (AVG) 132.00000
DEGREES OF FREEDOM FOR ERROR TERM 524
ERROR TERM 24.410000

TREATMENTS

ORDER	TREATMENT NR	MEAN
1	3	16.738000
2	2	9.5620000
3	1	9.0000000
4	4	6.5800000

TABLE OF Q-STATISTICS

VALUES FOR ROW 1

COLUMN	MEAN	VS	MEAN	R	DF	Q	.05	.01	VALUE
4	3		4	4	524	23.6217	3.69	4.50	**
3	3		1	3	524	17.9942	3.36	4.20	**
2	3		2	2	524	16.6873	2.80	3.70	**

VALUES FOR ROW 2

COLUMN	MEAN	VS	MEAN	R	DF	Q	.05	.01	VALUE
4	2		4	3	524	6.93443	3.36	4.20	**
3	2		1	2	524	1.30689	2.80	3.70	NOT-SIGN

VALUES FOR ROW 3

COLUMN	MEAN	VS	MEAN	R	DF	Q	.05	.01	VALUE
4	1		4	2	524	5.62754	2.80	3.70	**

The vowel [ω]

```
1BMD08VA -- UCLA 1965  (UT PSYCHOLOGY VERSION   1 AUG 1978)
0PROBLEM CODE:  SAMPLE      BY SQBY514   21 APR 87 13.11.14.
0 2 INDEPENDENT VARIABLES AND   1 DEPENDENT VARIABLES(  1 TYPE-I  1 TYPE-II)
   FORMAT CARDS WITH 10 ITEMS PER CARD.
0OPTIONS IN EFFECT
 F - TESTS,S UNEQUAL,

0INDEX              G    S
 NUMBER OF LEVELS   4   106
 POPULATION SIZE   004  INF
0DESIGN CARD       GS        G,S(G),$G.
0VARIABLE FORMAT     (10(F4.1,3X))

0               GROUP CONTROL CARDS

 GROUP  1 SIZE   22
 GROUP  2 SIZE   69
 GROUP  3 SIZE   35
 GROUP  4 SIZE  106
0UNWEIGHTED MEANS SOLUTION FOR VARIABLE S WITH  232 INSTANCES.

CORRECTION RATIO .38524566
1ANALYSIS OF VARIANCE FOR TYPE-I VARIABLE   1 AND TYPE-II VARIABLE   1
0      SOURCE          SUM OF        DF     MEAN          F-TEST  P(F)  ERROR
                       SQUARES              SQUARE                      TERM

   1  MEAN             11718.7        1   11718.7        1078.84 0.000  S(G)
   2  G                2558.30        3   852.766          78.51  .000  S(G)
   3  S(G)             2476.61      228   10.8623
0GRAND MEAN
0        8.4790806
0CELL MEANS
0     G =         1             2             3             4
             5.4091        8.5145        14.914        5.0425

2DATA FOR PROBLEM SAMPLE RUN BY SQBY514    21 APR 87 13.11.14.
1NEWMAN-KEULS TEST FOR ORDERED MEANS
                            DATA RUN  21 APR 87
```

The vowel [ω]

PROBLEM NAME - PFDURU1
NUMBER OF MEANS . 4
OBSERVATIONS PER MEAN (AVG) 40.000000
DEGREES OF FREEDOM FOR ERROR TERM 156
ERROR TERM 10.862300

TREATMENTS

ORDER	TREATMENT NR	MEAN
1	3	14.914000
2	2	8.5145000
3	1	5.4091000
4	4	5.0425000

TABLE OF Q-STATISTICS

VALUES FOR ROW 1

COLUMN	MEAN VS MEAN		R	DF	Q	.05	.01	VALUE
4	3	4	4	156	18.9432	3.69	4.50	**
3	3	1	3	156	18.2397	3.36	4.20	**
2	3	2	2	156	12.2805	2.80	3.70	**

VALUES FOR ROW 2

COLUMN	MEAN VS MEAN		R	DF	Q	.05	.01	VALUE
4	2	4	3	156	6.66268	3.36	4.20	**
3	2	1	2	156	5.95918	2.80	3.70	**

VALUES FOR ROW 3

COLUMN	MEAN VS MEAN		R	DF	Q	.05	.01	VALUE
4	1	4	2	156	.703496	2.80	3.70	NOT-SIGN

Bibliography

Abaurre-Gnerre, M. B. M. (1981). Processos fonológicos segmentais como índices de padrões prosódicos diversos nos estilos formal e casual do português do Brasil. In *Cadernos de estudos linguísticos*, 2, 23-44. Campinas, Brazil: Instituto de Estudos da Linguagem, Unicamp.

Abercrombie, D. (1967). *Elements of general phonetics*. Edinburgh: Edinburgh University Press.

Allen, G. D. (1972). The location of rhythmic stress beats in English: an experimental study I & II. In *Language and Speech*, 15, 72-100, 179-95.

Allen, G. D. (1973). Segmental timing control in speech production. In *Journal of phonetics*, 1, 219-37.

Allen, G. D. (1975). Speech rhythm: its relation to performance universals and articulatory timing. In *Journal of phonetics*, 3, 75-86.

Almeida, A. (1976). The Portuguese nasal vowels: phonetics and phonemics. In J. Schmidt-Radefeldt, ed., *Readings in Portuguese linguistics*, 349-96. Amsterdam: North-Holland Publishing, 349-96.

Barnwell, T. P. (1971). An algorithm for segment durations in reading machine context. In *Technical Report No. 479*. Cambridge, Ma: MIT. Electron. (unpub.)

Becker, R. A. and J. M. Chambers (1984). *S: An interactive environment for data analysis and graphics*. Belmont, Ca.: The Wadsworth Advanced Book Program.

Belasco, S. (1958). Variation in vowel duration: phonemically or phonetically conditioned? In Journal of the acoustical society of America, 30, 1049-50.

Borden, G.J. and K.S. Harris (1980). *Speech science primer: physiology, acoustics and perception of speech.* Baltimore, Md: The Williams and Wilkins Co.

Bortoni-Ricardo, Stella Maris (1985). *The urbanization of rural dialect speakers: a sociolinguistic study in Brazil.* Cambridge: Cambridge University Press.

BMDP-1977 (see Dixon, W.J. and M.B. Brown)

Bush, Clara (1964). *Phonetic variation and acoustic distinctive features.* The Hague: Mouton and Co.

Câmara, J. M., Jr. (1977). *Para o estudo da fonêmica portuguesa.* Rio de Janeiro, Br.: Padrão.

Câmara, J.M., Jr. (1968). Brazilian linguistics. In *Current trends in linguistics* (IV Ibero-American and Caribbean linguistics), 4, 229-47, Th. A. Sebeok, ed. The Hague, Paris: Mouton.

Câmara, J.M., Jr. (1969). *Problemas de lingüística descritiva*, 2a. edição. Petrópolis, Brasil: Editora Vozes.

Câmara, J.M., Jr. (1979). *História e estrutura da língua portuguesa.* Rio de Janeiro: Padrão -- Livraria e Editora Ltda.

Campos, G. Lino de. (1980). *Síntese de voz para o idioma português.* Ph. D. diss. (unpub.). São Paulo: Universidade de São Paulo.

Chafcouloff, M. and al (1976). Effets de la coarticulation sur les caracteristiques acoustiques des contoïdes fricatives du français. In *Travaux de l'Institut de phonétique d'Aix*, 3, 61-113.

Chistovich and al (1979). Centres of gravity and spectral peaks as the determinants of vowel quality. In *Frontiers of speech communication research*, B. Lindblom and S. Ohman, eds. London: Academic Press.

Cole, R.A., A.I. Rudnick, V.W. Zue and D.R. Reddy (1980). Speech as patterns on paper. In *Perception and production of fluent speech*, R.A. Cole, ed. Hillsdale, N.J.: Earlbaum.

Cole, R.A. and W.E. Cooper (1975). Perception of voicing in English affricates and fricatives. In *Journal of the acoustical society of America*, 58, 1280-87.

Cooper, W. E. (1976). The syntactic control of timing in speech production: a study of complement clauses. In *Journal of phonetics*, 4/2, 151-71.

Delattre, P. (1963). Research techniques for phonetic comparison of languages. In *International review of applied linguistics in language teaching*, I, 87-97.

Daniloff, R. and K. Moll (1968). Coarticulation of lip rounding. In *Journal of speech and hearing research*, II, 707-21.

Delattre, P. (1966). *Studies in French and comparative phonetics. Selected papers in French and English.* London, Paris, The Hague: Mouton and Cie.

Delattre, P. C., A. M. Liberman and F. S. Cooper (1955). Acoustic loci and transitional cues for consonants. In *Journal of the acoustical society of America*, 27, 769-74.

Denes, P. (1955). Effect of duration on the perception of voicing. In *Journal of the acoustical society of America*, 27, 761-64.

Denes, P.B. and E.N. Pinson (1963). *The speech chain: The physics and biology of spoken language*. Bell Telephone Labs.

Digital Sona-Graph, Model 7800, Instructional manual (1984). Pine Brook, NJ: Kay Elemetric Corp.

Dixon, W.J. and M.B. Brown (1977). *BMDP-1977: Biomedical computer programs, P-series*. Berkeley: University of California Press.

Fant, C.G.M. (1970). *Acoustic theory of speech production*, 2nd ed. The Hague: Mouton.

Farr, R. (1982). Computador que fala por fonema é projeto do CNPq. In *Jornal do Brasil*, Caderno Especial, 27 de junho.

Faure, G., D. J. Hirst, and M. Chafcouloff (1980). Rhythm in English: isochronism, pitch, and perceived stress. In *The melody of language*, L. R. Waugh and C. H. van Schooneveld, eds, 71-79. Baltimore: University Park Press.

Ferrero, F.E. and al (1979). Fricative duration of Italian unvoiced fricatives. In *Frontiers of speech communication research*, B. Lindblom and S. Ohman, eds. New York: Academic Press, 159-65.

Fry, D.B., ed. (1976). *Acoustic phonetics -- a course of basic readings*. Cambridge: Cambridge University Press.

Fry, F.B. (1955). Duration and intensity as physical correlates of linguistic stress. In *Journal of the acoustical society of America*, 27, 4.

Fry, F.B. (1979). *The physics of speech*. Cambridge: Cambridge University Press.

Gerstman, L. (1956) "Noise duration as a cue for distinguishing among fricative, affricates, and stop consonants." In *Journal of the acoustical society of America*, 28, 1, 160.

Gleason, H.A. (1955). *An introduction to descriptive linguistics*. New York: Holt, Rinehart and Winston.

Grammont, M. (1933). *Traité de phonétique*. Paris: Delagrave.

Gross, M. (1968). L'emploi des modèles en linguistique. In *Langages*, 9, 4-8. Paris.

Hall, R. A., Jr. (1943a). The unit phonemes of Brazilian Portuguese. In *Studies in linguistics*, 1 (15), 1-7.

Harris, M.S. and N. Umeda (1974). Effect of speaking mode on temporal factors in speech. In *Journal of the acoustical society of America*, 56, 1016-18.

Hayes, B. (1984). The phonology of rhythm in English. In *Linguistic Inquiry*, 15, 33-74.

Head, B. F. (1964). *A comparison of the segmental phonology of Lisbon and Rio de Janeiro*. Ph. D. diss. Austin, Tx: The University of Texas.

Heinz, J. M. and K. N. Stevens (1961). On the properties of voiceless fricatives consonants. In *Journal of the acoustical society of America*, 33, 589-96.

House, A. and G. Fairbanks (1953). Influence of consonant environment upon the secondary acoustical characteristics of words. In *Journal of the acoustical society of America*, 25, 105-113.

Huggins, A.W.F. (1964). Distortion of the temporal pattern of speech: interruption and alternation. In *Journal of the acoustical society of America*, 36, 1055-64.

Huggins, A.W.F. (1972a). Just noticeable differences for segment duration in natural speech. In *Journal of the acoustical society of America*, 51(2), 1270-78.

Huggins, A.W.F. (1972b). On the perception of temporal phenomena in speech. In *Journal of the acoustical society of America*, 51(2), 1279-1290.

Jakobson, R. (1949). On the identification of phonemic entities. In *Travaux du cercle linguistique de Copenhagen*, V, 205-13.

Jackobson, R., G. Fant and M. Halle (1952). *Preliminaries to speech analysis*, 8th ed. (1969). Cambridge, Ma.: MIT.

Jassem, W. (1968). Acoustical description of voiceless fricatives in terms of spectral patterns. In *Speech analysis & synthesis*, 1, 189-206.

Jassem, W. (1965). The formants of fricative consonants. In *Language and speech* (Middlesex), 8, 1-16.

Kim, J. and P.F. MacNeilage (1973). Voiceless consonant durations in VCV utterances. In *Journal of the acoustical society of America*, 53, 1, 379 (A).

Klatt, D.H. (1974). The duration of [s] in English words. In *Journal of speech hearing research*, 17, 51-63.

Klatt, D.H. (1972). Generative theory of segmental duration in English. In *Journal of the acoustical society of America*, 51, 101(A).

Klatt, D.H. (1973b). Interaction between two factors that influence vowel duration. In *Journal of the acoustical society of America*, 54, 1102-04.

Klatt, D.H. (1976). Segmental duration in English. In *Journal of the acoustical society of America*, 59, 1208-21.

Klatt, D.H. (1975a). Vowel lengthening is syntactically determined in a connected discourse. In *Journal of phonetics*, 3, 129-40.

Klatt, D.H. (1975b). Perception of segment duration in sentence contexts. In *Structure and process in speech perception*, A. Cohen and S. Noteboom, eds. Heidelberg: Springer Verlag.

Kloker, D. (1975). Vowel and sonorant lengthening as cues to phonological phrase boundaries. In *Journal of the acoustical society of America, 57, 533(A).*

Kozhevnikov, V.A. and L.A. Chistovich (1965). Speech articulation and perception. *JPRS* 30. Washington, DC.

Ladefoged, P. (1962). *Elements of acoustic phonetics*. Chicago: The University of Chicago Press.

Ladefoged, P. (1975). *A course in phonetics*. New York: Harcourt Brace Jovanovich.

Landercy, A. and R. Renard (1977). *Eléments de phonétique*. Brussels: Didier.

Lass, N.J., ed. (1976) *Contemporary issues in experimental phonetics*. New York: Academic Press.

Lehiste, I (1977). Isochrony reconsidered. In *Journal of phonetics*, 5, 253-63.

Lehiste, I. (1979). Perception of sentence and paragraph boundaries. In *Frontiers of speech communication research*, B. Lindblom and S. Ohman, eds. New York: Academic Press, 191-201.

Lehiste, I., ed. (1967) *Readings in acoustic phonetics*. Cambridge, Ma: The MIT Press.

Lehiste, I. (1973). Rhythmic units and syntactic units in production and perception. *Journal of the acoustical society of America*, 54, 1228-34.

Lehiste, I. (1970). *Suprasegmentals*. Cambridge, Ma: MIT Press.

Lehiste, I. and G.E. Peterson (1961). Transitions, glides, and diphthongs. In *Journal of the acoustical society of America*, 33, 268-77.

Liberman, A.M., F.S. Cooper, D.P. Shankweiler, and M. Studdert-Kennedy (1967). Perception of the speech code. In *Psychology review*, 74, 431-61.

Liberman, M. and A. Prince (1977). On stress and linguistic rhythm. In *Linguistic inquiry*, 8, 249-336.

Lieberman, Ph. (1977). *Speech physiology and acoustic phonetics: an introduction*. New York: MacMillan Pub.

Liljencrants, J. and B. Lindblom (1972). Numerical simulation of vowel quality systems: the role of perceptual contrast. In *Language*, 48, 839-862.

Lindblom, B. (1961). Accuracy and limitations of Sona-Graph measurements. In *Proceedings of the 4th international congress of phonetic sciences*, Helsinki.

Lindblom, B. (1971). Numerical models in the study of speech production and perception. Some phonological implications. In *Papers from the Institute of linguistics*, University of Stockholm, 7, 1-15.

Lindblom, B. (1971). Phonetics and the description of language. In *Proceedings of the VII international congress of phonetic sciences*, Montreal, A. Rigault and R. Charbonneau, eds. The Hague: Mouton, 63-97.

Lindblom, B. (1973). Spectrographic study of vowel reduction. In *Journal of the acoustical society of America*, 35, 1773-81.

Lindblom, B. (1978). Final lengthening in speech and music. In *Travaux de l'Institut de phonêtique de Lund*, 13.

Lindblom, B., B. Lyberg, and K. Holmgren (1981). *Durational patterns of Swedish phonology: do they reflect short-term motor memory processes?* Indiana, Bloomington: Indiana University Linguistic Club.

Lindblom, B. and S. Ohman, eds. (1979). *Frontiers of speech communication research.* New York: Academic Press.

Lindblom B. and K. Rapp (1973). *Some temporal regularities of spoken Swedish.* Publication no. 21. Stockholm: Institute of linguistics of the University of Stockholm (unpub.).

Lindblom, B. and J. Sundberg (1971). Acoustical consequences of lip, tongue, jaw, and larynx movement. *Journal of the acoustical society of America,* 50, 1166-79.

Lindblom, B. and J. Sundberg (1969). A quantitative model of vowel production and the distinctive features of Swedish vowels. In *Speech transmission laboratory quarterly progress report* 1, 14-31.

Lisker, L., and A.S. Abramson (1964). A cross-language study of voicing in initial stops: acoustical measurements. In *Word* 20, 384-422.

Lyberg, B. (1979). Final lengthening -- partly a consequence of restrictions on the speed of fundamental frequency change? In *Journal of phonetics,* 7, 187-96.

Lyberg, B. (1981). Some consequences of a model for segment duration based on F_o-dependence. In *Journal of phonetics,* 9, 97-103.

Lyberg, B. (1981). Some observations on the vowel duration and the fundamental frequency contour in Swedish utterances. In *Journal of phonetics*, 9, 261-72.

MacNeilage, P. F. (1970). Motor control of serial ordering in speech. In *Psychological review*, 77, 182-96.

MacNeilage, P. F. and J. L. DeClerk (1969). On the motor control of coarticulation in CVC monosyllables. In *Journal of the acoustical society of America*, 45, 1217-33.

Major, R. (1981). Stress-timing in Brazilian Portuguese. In *Journal of phonetics*, 9, 343-51.

Major, R. (1985). "Stress and rhythm in Brazilian Portuguese". In *Language*, 61, no. 2, 259-89.

Martin, J.G. (1972). Rhythmic (hierarchical) versus serial structure in speech and other behaviors. In *Psychological review*, 79, 487-509.

Martinet, A. (1949). Phonology as functional phonetics. *Publications of the Philological society*, no. 15. London: Oxford University Press, 1-27.

Mattoso Câmara, Jr., M. (see Câmara, J.M., Jr.)

Menzerath, P. and A. de Lacerda (1933). *Koartikulation, Steuerung und Lautabgrenzung*. Berlin.

Miller, G.A. and P.E. Nicely (1955). An analysis of perceptual confusion among some English consonants. In *Readings in acoustic phonetics*, 301-15.

Noteboom, S.G. (1972). Temporal patterns in Dutch. In *Proceedings of the 7th international congress of phonetic sciences*, 984-89.

Ohman, S.E.G. (1966). "Coarticulation in VCV utterances: spectrographic measurements". In *Journal of the acoustical society of America*, 39, 151-68.

Ohman, S.E.G. (1967). Numerical model of coarticulation. In *Journal of the acoustical society of America*, 41, 310-28.

Oller, D. K. (1973). The effect of position in utterance on speech segment duration in English. In *Journal of the acoustical society of America*, 54, 1235-47.

Parker, E.M. and R.L. Diehl (1984). Identifying vowels in CVC syllables: effects of inserting silence and noise. In *Perception & psychophysics*, 36 (4), 369-80.

Peterson, G.E. and I. Lehiste (1960). Duration of syllable nuclei in English. In *Journal of the acoustical society of America* 32, 693-703.

Pike, K. L. (1945). *The intonation of American English.* Ann Arbor: University of Michigan Press.

Potter, R.K., G.A. Kopp, H.G. Kopp (1966). *Visible speech.* New York: Dover Publications, Inc.

Prince, A. (1983). Relating to the grid. In *Linguistic inquiry*, 14, 19-100.

Raphael, L. (1972). Preceding vowel duration is a cue to the perception of the voicing characteristics of word final consonant in American English. In

Journal of the acoustical society of America 51, 1296-1303.

Schreiber, P.A. and W.Ch. Read (1982). Why short subjects are harder to find than long ones. In *Language acquisition: the state of the art*, Wanner and Gleitman, eds. Cambridge, Ma.: Cambridge University Press.

Selkirk, E.O. (1980). The role of prosodic categories in English word stress. In *Linguistic inquiry*, 11, 563-605.

Simões, A. R. M. (1980). Etude acoustique des consonnes [s] et [z] du Brésilien". Mémoire de D.E.A., ms. Aix-en-Provence, France: Institut de phonétique.

Stevens, K. N. (1972). The quantal nature of speech: evidence from articulatory-acoustic data. In *Human communication: a unified view*, David, E. and P. Denes, eds. New York: MacGraw-Hill, 51-66.

Stockwell, R. P. (1977). *Foundations of syntactic theory*. Englewood Cliffs, New Jersey: Prentice-Hall.

Strevens, P. (1960). Spectra of fricative noise in human speech. In *Language and speech*, 3, 33-49.

Umeda, N. (1975a). Vowel duration in American English. In *Journal of the acoustical society of America*, 58, 434-45.

Umeda, N. (1975b). Another consistency in phoneme duration. In *Journal of the acoustical society of America*, 58, S62 (A).

Umeda, N., R. B. Monsen, and M. Molter (1973). Fricative -- the physical properties and allophones. *Journal of the acoustical society of America*, 53, 373(A).

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