

Faculdade de Letras  
da Universidade de Lisboa

# *Prosódia*

Seminário de pós-graduação em Linguística

Relatório

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**Note:**

This is a summary translation of sections of the original report on the graduate course on Prosody. The target sections that have been summarized in this translation are signaled by an \* in the TOC (page numbers in the TOC refer to the original report).

The author gently asks the reader to refer to the original version for listening to the sound examples, and for full information.

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## **1. INTRODUCTION**

### **1.1. THE OBJECT OF THE REPORT**

Three main reasons led to the choice of the graduate course on Prosody as the object of this report:

- (i) Prosody is almost not taught at the undergraduate level, although it is extremely important to the knowledge of language structure, language production and comprehension, and language use;
- (ii) The challenge of the marriage between an introductory approach and an approach which integrates recent research methods and findings into the teaching of prosody;
- (iii) Recent developments in prosodic studies from a multidisciplinary perspective, as well as the research conducted at CLUL/FLUL (mainly at the Phonetics lab and Lisbon baby lab), lay the ground for a graduate course that may be of interest to students from various scientific backgrounds.<sup>1</sup>

### **1.2. THE OUTLINE OF THE REPORT**

## **2. THE TEACHING OF PROSODY AT THE DEPARTAMENTO DE LINGUÍSTICA GERAL E ROMÂNICA**

## **3. THE PHONETICS: PROSODY GRADUATE COURSE**

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<sup>1</sup> The graduate program in Linguistics is open to prospective graduate students from any scientific domain. Research activities in which the Phonetics lab and Lisbon baby lab has been involved that are considered relevant to the graduate course include the *Research Network - Forms and Function of Prosodic Structure* (<http://www.let.ru.nl/gep/intproj/>), the network of projects producing intonation and prosody Atlas for several Romance Languages (Catalan, Spanish, Occitan, Portuguese, Italian, French, Sardinian) with the major goal of leading to an Atlas of Romance Intonation (<http://prosodia.upf.edu/activitats/wromtobi/home/index.php>), and the projects on prosodic development in English, Catalan and Spanish (APriL Project, <http://april-project.info/>), and in European Portuguese (*Development of prosodic structure and intonation (DEPE)* <http://www.fl.ul.pt/LaboratorioFonetica/babylab/pt/projectos.html>).

(Hereafter Prosody)

### **3.1. THE GRADUATE PROGRAM IN LINGUISTICS**

### **3.2. THE PROSODY COURSE WITHIN THE GRADUATE PROGRAM**

### **3.3. GOALS OF THE PROSODY COURSE**

The main lines and goals of the Graduate Program in Linguistics naturally constrain the specific goals of the Prosody course. Especially relevant are the following:

- (i) The goal to develop capacities for original research or for the fulfillment of professional activities involving specialized knowledge in linguistics;
- (ii) The program flexibility, in that individual courses may be freely combined so that each student may design his/her own path in the program;
- (iii) The opening to students from any scientific domain.

Consequently, the Prosody course is designed to combine an introductory level approach with advanced level knowledge, by providing basic notions in prosody, promoting the use of elementary methods of prosodic analysis, and encouraging experimental research and the discussion of the results obtained.

The specific goals of the Prosody course are the following:

1. To understand the prosodic component of language.
2. To be able to identify and classify the rhythms and melodies of language: listen, identify/compare, transcribe.
3. To handle experimental methods in prosody research (for the study of prosodic structure, rhythm, intonation; production, perception, comprehension).
4. To develop empirical research in prosody.



#### **4. SHORT DESCRIPTION OF THE PROSODY COURSE**

##### **4.1. PROGRAM OF THE PROSODY COURSE**

### PROSODY Program

#### 1. FUNDAMENTAL CONCEPTS OF PROSODY

- 1.1. Organizing speech into prosodic constituents: the prosodic structure
- 1.2. Prosodic structure, rhythmic structure and intonation structure: prominence, rhythm and intonation

#### 2. PROSODIC DOMAINS

- 2.1. Prosodic domains in Portuguese
- 2.2. On the nature of prosodic structure
- 2.3. Defining prosodic constituents and levels of phrasing

#### 3. RHYTHM

- 3.1. Notions of rhythm
- 3.2. Different approaches to rhythm: between phonetics and phonology
- 3.3. Rhythmic space: classes or a continuum?
- 3.4. Analysing rhythm in production and perception: the case of Portuguese
- 3.5. Correlations and explorations: phonology, lexicon, evolution of rhythm

#### 4. INTONATION

- 4.1. Melody in language: tonal languages and intonational languages
- 4.2. Phonetics and phonology of intonation
- 4.3. Analysing intonation: the case of Portuguese
- 4.4. Intonational variation: varieties of Portuguese and Romance languages

#### 5. PROSODY AND MEANING

- 5.1. Prosody and language processing by adult speakers
- 5.2. Prosody and language processing by babies and children

## 6. PROSODY AND LANGUAGE ACQUISITION

### 6.1. Rhythm and language acquisition

### 6.2. Acquisition of intonation

### 6.3. Prosodic development

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#### 4.3. OBSERVATIONS ON THE PROGRAM AND BIBLIOGRAPHY

The program of the Prosody course is organized into 6 sections.

The 1st section is an introduction to prosody, where the fundamental concepts necessary to the development of the other 5 sections are presented.

Sections 2, 3 and 4 respectively focus on prosodic constituents, rhythm and intonation. These sections are conceived as independent from one another. However, the sequential ordering explicitly favours an understanding of the sound structure of language as a prosodic constituent structure, which is manifested by external sandhi phenomena, prominence relations and rhythmic phenomena, and intonational phenomena such as the distribution of tonal events. Within each section, the departure point assumes an introductory level and the use of elementary methods in prosody analysis. The raising of specific questions and hypotheses towards the exploration of ways to tackle them follows, as a window into more advanced knowledge and research. Along this path, the description of the prosody of Portuguese (especially European Portuguese), within a cross-linguistic perspective, has a special role.

Sections 5 and 6 are also independent from each other. However, they presuppose that the contents from the previous sections were learnt and the respective competences were acquired. In sections 5 and 6, prosodic structure, rhythm and intonation are seen from the perspective of language processing (section 5) and language acquisition (section 6). In section 5, the role of prosody in lexical and syntactic processing is highlighted. In section 6, we focus on the role of prosody in the acquisition of various linguistic units and structures (prosodic bootstrapping), along with the description of prosodic development. As before, special reference is made to studies on Portuguese.

The program of the Prosody course has a strong empirical and experimental commitment, in line with the goals of the course (see section 3.3): it is expected that active understanding of the prosodic component of language is attained, via the use of methods in empirical prosody research and their application in small research projects.

The general bibliography that accompanies the program follows 3 main criteria: (i) it contains both introductory level texts and intermediate/advanced level texts; (ii) it contains both a selection of texts on the prosody of Portuguese within a cross-linguistic approach and texts on the prosody of various languages, in either case using a homogenous framework and resorting to experimental approaches; (iii) the texts should be easily accessible, especially by means of on-line resources. The general bibliography is announced, together with the program, one year before the beginning of the course.

During the course, specific references will be provided for each section. Although many of the references will come from the general bibliography, some of them may be new to students, because they were oriented towards particular issues, or they have been recently made available, or they respond to specific needs posed by individual students. The final bibliography of the course should thus be seen as flexible and open. At the end of the course, an extended bibliography is provided (see Appendix).

#### **4.4. COURSE PLANNING**

### **5. *TEACHING METHODS***

#### **5.1. METHODS AND RESOURCES**

#### **5.2. EVALUATION**

### **6. *CONTENTS OF THE PROSODY COURSE***

*Nenhum vento sopra a favor  
de quem não sabe para onde ir*  
Sêneca

*Things should be made as simple  
as possible,  
but not any simpler.*  
Albert Einstein

For each of the 6 sections of the course's program, a summary of the contents is provided, potential lines of research are presented, and specific references are given. As mentioned above (in section 4.3), within each section a path is followed from an introductory level approach into the raising of questions and hypothesis directed towards research. Special attention is given to the prosody of Portuguese (standard variety, spoken in the Lisbon area).

## 6.1. FUNDAMENTAL CONCEPTS OF PROSODY

### 1. FUNDAMENTAL CONCEPTS OF PROSODY

#### 1.3. Organizing speech into prosodic constituents: the prosodic structure

#### 1.4. Prosodic structure, rhythmic structure and intonation structure: prominence, rhythm and intonation

The 1st section is an introduction to prosody, where the fundamental concepts necessary to the development of the other 5 sections are presented.

The view that prosodic structure has a role to play as the organizing framework of speech is well established. This structure consists of the grouping of chunks of speech into prosodic constituents arranged according to a hierarchy, delimited by prosodic boundaries or edges and with prominences or heads at the various levels (Figure 1).

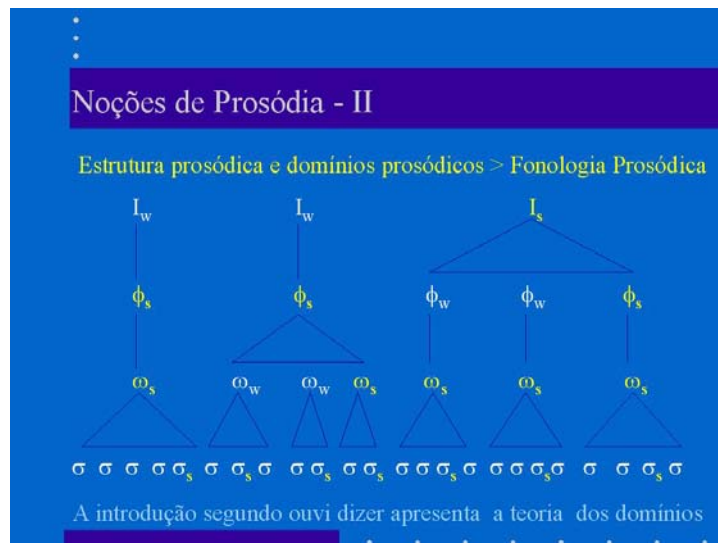




Figure 1. Illustrating prosodic structure, from the syllable to the Intonational phrase.

Prosodic domains are marked by constellations of cues, which stand as the major empirical evidence for prosodic structure and the constituents it comprises. Among these cues, we find phenomena showing that the way segments are realized (or tones, in tonal languages) is contingent on prosodic structure: sandhi phenomena (1a), initial strengthening (1b), or final lengthening



(Figure 2). Rhythmic phenomena are also sensitive to prosodic structure: for example, stress clash resolution may crucially depend on the prosodic organization of the clashing syllables into the same constituent (2). The way tonal events are realized, as well as their distribution, also reflects prosodic structure: for example, the relative height of a tone may depend on it being realized within the same constituent as the previous tones, or as the initial tone of a new prosodic phrase (3), and the distribution patterns of tonal events cue the prosodic structure of the speech sequence they are associated to (4).

- (1)  a. [ a[z] angolana[z] ofereceram especiaria[z] [ɔʃ] jornalista[ʃ] ]<sub>I</sub>  
 b. [ a[z] angolana[z] ofereceram especiaria[ʃ] ]<sub>IP</sub> [ [awʃ] jornalista[ʃ] ]<sub>I</sub>  
 ‘The Angolan women offered spices to the journalists’

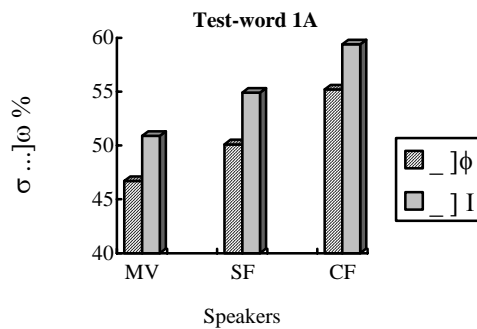
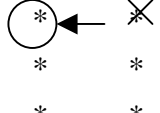
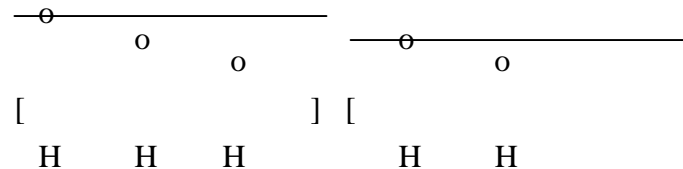


Figure 2. Final lengthening at phonological phrase and intonational phrase boundaries, for the test-word *progressiva*. Mean duration of the stressed and final unstressed syllables, expressed as a percentage of the test-word duration, for 3 speakers (Frota 2000, p.192).

- (2) a.  \* \* \* b. \* \*  
 \* \* \* \* \*  
 \* \* \* \* \*  
 [thirteen men]φ Tennessee]φ won

- (3)   
 [ H L L ] [ H L ]

- (4) uma grande subida dos preços      'a large rise in prices'
- T      T      T
- T      T > [uma grande subida]<sub>φ</sub> [dos preços]<sub>φ</sub>
- \*      T      T > [uma grande subida dos preços]<sub>φ</sub>

The implementation of rhythmic and tonal properties shows that prosodic structure plays a relevant role in language rhythm and intonation. Prosodic structure defines the prosodic heads (prominent elements) and the prosodic edges available as possible anchors for tonal association. Culminative or accentual tonal events (pitch accents) are linked to prominent elements, namely to heads of prosodic constituents, and contribute to the realization of prominence. Demarcative tonal events, or boundary tones, are linked to the edges to prosodic constituents (Figure 3). Intonation structure is thus related to prosodic structure.

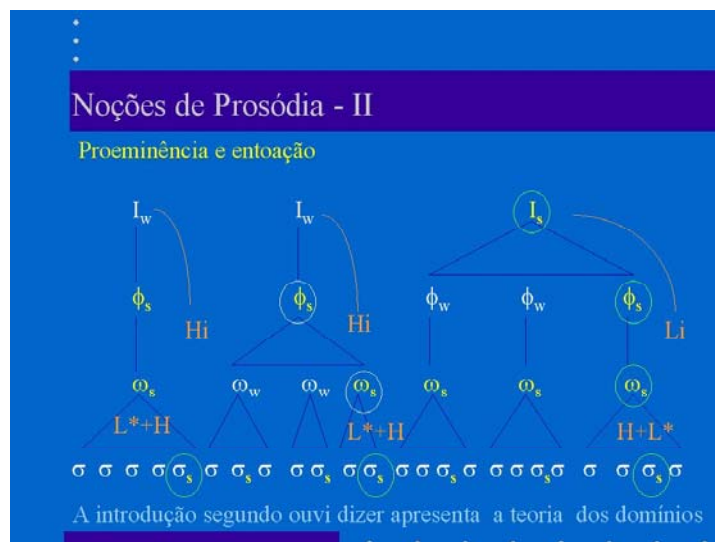


Figure 3. Prosodic structure, prominence and tonal events.

The cues to prosodic structure have been shown to be used in lexical processing, in the disambiguation of syntax (see section 5 of the program), or in the identification of morpho-syntactic units and of (other) phonological units in language acquisition (see section 6 of the program).

### Specific references

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## 6.2. PROSODIC DOMAINS

### 2. PROSODIC DOMAINS

#### 2.1. Prosodic domains in Portuguese

#### 2.2. On the nature of prosodic structure

#### 2.3. Defining prosodic constituents and levels of phrasing

Section 2 of the course program is devoted to the study of prosodic constituents. This study is focused on the constituents above the word level, given their relevance to rhythm and intonation. The language for data analysis is mainly European Portuguese (EP).

There are (at least) three basic observations about prosodic structure: prosodic constituency is non-isomorphic to morpho-syntactic constituency and thus is properly phonological; prosodic constituents are metrical constituents of some sort that are hierarchically structured; the limits of higher constituents are also the limits of lower level constituents.

Assuming the prosodic phonology approach, prosodic domains partially result from the interface of phonology with other components of grammar, and thus bears some systematic relation to morpho-syntax. These interface constraints, together with phonology proper constraints, determine prosodic structure. This is illustrated with the study of the phonological phrase and the intonational phrase in several languages. Prosodic domain formation shows two basic principles of the prosodic organization of speech in action: the demarcative principle, implemented by a syntax-phonology mapping oriented towards the edges of designated syntactic constituents (5a); and the grouping principle, implemented by a mapping oriented towards the relations that hold between constituents (5b).

- (5) a. Alignment between edges of designated syntactic constituents and edges of prosodic constituents

e.g. phonological phrase

Japanese {Left, XP} Chi Mwi:ni {Right, XP}

- b. Relation between heads and adjacent constituents (head/complement, head/modifier, etc)

e.g. phonological phrases

Papago, Chichewa {Wrap, XP}

Typically, phonological constraints on prosodic constituents refer to size, weight, balance, or (a)symmetry, as illustrated in (6).

- (6) Phonological phrase: Italian (Ghini 1993)

{Right, XP} ( ω ω ω ω ω ) φ  
 ( ω ω ) φ ( ω ) φ ( ω ω ) φ  
 ( ω ) φ ( ω ω ) φ ( ω ω ) φ  
 ( ω ω ) φ ( ω ω ω ) φ  
 \*( ω ω ) φ ( ω ω ) φ ( ω ) φ  
 \*( ω ω ω ) φ ( ω ω ) φ  
 \*( ω ) φ ( ω ω ω ) φ ( ω ) φ  
 \*( ω ) φ ( ω ) φ ( ω ω ) φ ( ω ) φ

Within this framework of analysis, phonological phrase and intonational phrase formation in EP are studied, and the phonetic and phonological properties that cue these prosodic domains are described. For both domains it is shown the relevance of the grouping principle (relation-based mapping), and of phonological restrictions.

Like in many other languages, phonological phrase formation in EP applies within the maximal projection of a lexical head ( $Lex^{max}$ ). A phonological phrase ( $\phi$ ) in EP includes the lexical head and the elements on the head's nonrecursive side within  $Lex^{max}$ . A following phrase also within the  $Lex^{max}$  domain may be contained in the same  $\phi$ , if this phrase is not able to form a  $\phi$  on its own. The inclusion of this phrase reflects the presence of phonology proper restrictions over phonological phrases: namely, a minimal size restriction that determines that a  $\phi$  should contain more material than a prosodic word. Prominence within  $\phi$  is rightmost, that is, the final prosodic word is the  $\phi$ -head, as in most languages with the syntactic order head-complement. The empirical demonstration of this analysis is based on durational evidence connected with

rhythmic phenomena (Figure 4), segmental evidence from the (non)application of vocalic sandhi induced by rhythmic restrictions (7), and intonational evidence from the distribution patterns of pitch accents (see (4) above).

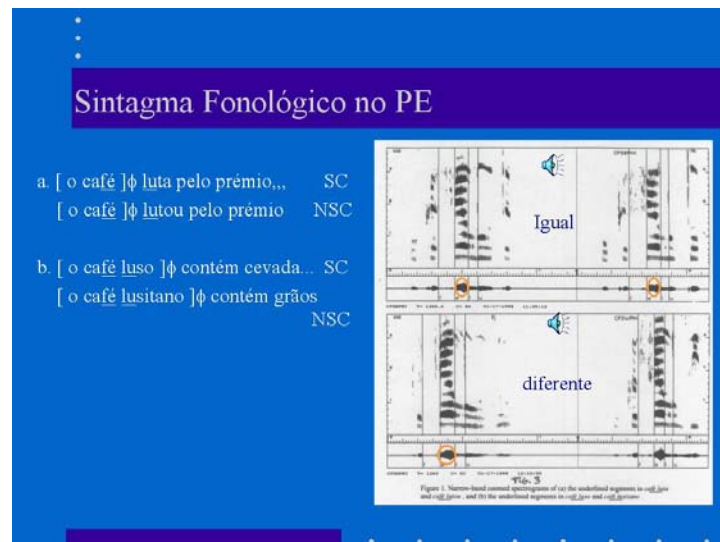



Figure 4. The phonological phrase and the lengthening of the 1st of two adjacent stressed syllables, within the same  $\phi$ . [  ]

(7) Targets vowels underlined, stressed syllables in capitals,  $\phi$ -head in bold

[ o **dança**RIno ]  $\phi$  [ **A**ma ]  $\phi$  [ a bailarina **rus**sa ]  $\phi$

\*dançarinama (<dançarino+ama)

‘The dancer loves the Russian ballerina’

[ o **baila**RIno ]  $\phi$  [ **A**Nda **SEM**pre ]  $\phi$  [ de limusine **pre**ta ]  $\phi$

<sup>ok</sup>bailarinanda (<bailarino+anda)

‘The dancer always drives a black limousine’

An application of the demarcative principle in the mapping, whether the right or the left edge are selected (see respectively (8a) and (8b) ), yields a prosodic structure that does not account for the phonetic and phonological properties described.<sup>2</sup> The example in (8) shows that the prosodic structure obtained is (8a) in i. but (8b) in ii., that is it always corresponds to the grouping of N and A apart from PP, and not to right-edge or to left-edge mapping.

<sup>2</sup> Note that, in line with observations for other Romance languages, lexical heads only count as prosodic heads when they occur in their unmarked position (in the case of the adjective, on the recursive side – cf. Nespor & Vogel 1986).

- (8) i. [ N [ A ]<sub>AP</sub> PP ]<sub>NP</sub>                      ii. [ A N PP ]<sub>NP</sub>  
 (a) ✓ (                      )<sub>φ</sub> (                      )<sub>φ</sub>  
 (b) (                      )<sub>φ</sub> (                      )<sub>φ</sub>                      ✓ (                      )<sub>φ</sub> (                      )<sub>φ</sub>

The intonational phrase (I) groups all adjacent  $\phi$ s within a root sentence;  $\phi$ s in a string not structurally attached to the sentence tree form an independent IP on their own (e.g. parenthetical phrases, explicative phrases/clauses, tags, vocatives, topics).<sup>3</sup> This mapping groups within the same I-phrase constituents that hold a head/complement or a head/modifier relation. I-phrases are constrained by phonological conditions that interact with the mapping principles yielding the prosodic organization into Is that is found in speech. These conditions are weight conditions: long phrases tend to be divided, balanced phrases or the longest phrase in the rightmost position are preferred. Prominence within the I-phrase is rightmost, by default. That is, the head of the final  $\phi$  gets I-level prominence.

There is abundant evidence for this level of phrasing in EP. The I-phrase bounds the application of many sandhi rules (such as Syllable Degemination, Vowel Merger, Vowel Deletion, Semivocalization, and Fricative Voicing – see (1) above and also (9) below). The I-phrase is the domain for pre-boundary lengthening (already illustrated in Figure 2) and it defines the locus for pauses. The intonational phrase also has a precise intonational definition: it is the domain of the minimal tune in EP, as only the I-head must be pitch-accented and only the right-edge of the I-phrase requires tonal boundary marking in the language. In Figure 5, the contrast between [as alunas] produced as a  $\phi$  or as an I is shown, both by means of the pitch contour and the way the final fricative of *alunas* is realized. The two utterances have different syntactic structures, with different interpretations ('até ao nono ano' is a modifier of 'alunas' in the first case, and an adverbial expression modifying the whole action in the second case).

- (9) a. [ a[z] aluna[z] obtiveram boa[z] avaliaçõe[ʃ] ]<sub>I</sub>  
 'The students have got good marks'

<sup>3</sup>Depending on the syntactic approach, the domain for I-formation has been identified as the *Extended Projection of VP*, or the *Comma Phrase* (see, respectively, Elordieta et al. 2005, Selkirk 2005). In the course we follow a more classical approach, without entering into the discussion of the syntactic analysis of the different structures.

b. [ a[z] aluna[f] ]<sub>I</sub> [ até onde pensamo[f] e sabemo[f] ]<sub>I</sub> [ obtiveram  
boa[z] avaliação[f] ]<sub>I</sub>

'The students, as far as we think and know, have got good marks'

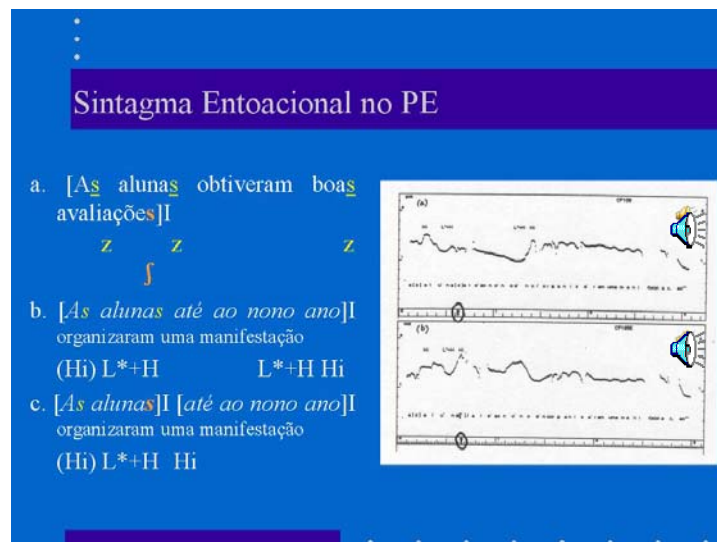


Figure 5. Segmental and intonational evidence for the I-phrase.

(b) 'The students (from all the grades) up to the 9<sup>th</sup> grade have organized a demonstration. (c) The students, until the 9<sup>th</sup> grade, organized a demonstration.

The role played by phonological restrictions on I-phrasing is illustrated in (10): the contrast between (a'') e (b'') is accounted for by the preference to have the longest phrase in the rightmost position.

- (10) a. [ O galã andava de porsche ]<sub>I</sub>  
 a'. [ O galã ]<sub>I</sub> [ andava de porsche ]<sub>I</sub>  
 a''.\* [ O galã andava ]<sub>I</sub> [ de porsche ]<sub>I</sub>  
 'The hero used to drive a Porsche.'  
 b. [ O poeta cantou uma manhã angelical perturbadora ]<sub>I</sub>  
 b'. [ O poeta ]<sub>I</sub> [ cantou uma manhã angelical perturbadora ]<sub>I</sub>  
 b''. [ O poeta cantou ]<sub>I</sub> [ uma manhã angelical perturbadora ]<sub>I</sub>  
 'The poet sang a disturbing angelic morning.'

The phonetic and phonological properties of the phonological phrase and the intonational phrase in EP are summarised in Table 1.

Table 1. EP prosodic structure: properties of  $\phi$  and I (Frota, in press).

Properties	Segmental	Durational	Tonal	Prominence
PhP	NO	NO	NO	Rightmost (default) PhP heads constrain the output of vowel sandhi <i>Domain</i> for stress strengthening
IP	<i>Domain</i> for many segmental processes <i>Domain</i> for resyllabification <i>Left edge</i> : reduced forms of proclitics are highly disfavoured	Final lengthening IP-edge: Locus of pauses	<i>Domain</i> for pitch accent distribution: IP heads require a pitch accent <i>Right edge</i> requires boundary tone <i>Left edge</i> optionally marked	Rightmost (default) Focus prominence (not positional)

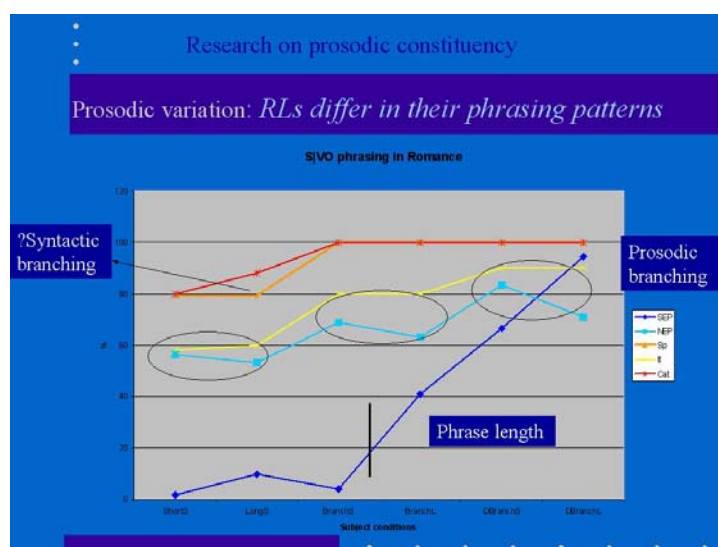


Figure 6. Prosodic organization into intonational units: variation across languages/varieties. Size (short/long) and complexity (non-branching, single branching, double branching).

The various factors that may determine the prosodic organization into intonational constituents can be implemented in different ways in the phonological grammars of different languages, even in the case of closely related languages or language varieties. This is illustrated by the behaviour of



Catalan, Italian, Spanish, Standard European Portuguese and Northern European Portuguese, with respect to the phrasing of a SVO utterance into the two intonational units (S) (VO) when prosodic size in number of syllables and syntactic and prosodic complexity are systematically varied (Figure 6).

The framework of analysis of prosodic constituents described above has provided interesting findings that stand as a major contribution to the present knowledge of prosodic structure in language. Two essential questions on the nature of prosodic structure, however, remain open to debate: are there different kinds of such structures or instead a unique representation that governs phenomena as varied as those mentioned above?; how is a prosodic constituent defined (are levels of constituency and of phrasing equivalent in prosodic structure)?

The first question calls for the discussion of the different views of prosodic structure have been proposed both in the general literature on prosody and in the laboratory phonology literature: namely, a structure that results from the combination of phonological restrictions with interface constraints between phonology and other grammatical components (the dominant view in prosodic phonology), or an intonation and prominence-based structure exclusively defined on the basis of intonation and prominence properties that characterize the constituents posited (and labelled) with reference to these phenomena (a common approach in intonation studies). This question must be addressed empirically, by means of the development of experimental paradigms that control and provide a test for the (various) properties of prosodic structure.

The second question is strongly connected with the recursivity issue. In most approaches to prosodic structure, whether rule-based or intonation/prominence-based, this structure is considered to be fundamentally different from morpho-syntactic structure in that it is crucially flatter. However, some forms of (prosodic) recursivity have been proposed, which entail that the levels of prosodic constituency do not necessarily correspond to the levels of phrasing. Given that many phonetic cues for the prosodic organization of speech tend to signal levels of phrasing, the definition of prosodic constituents results less clear. Again, the answer lies in experimental approaches that may distinguish between differences in type (pointing to distinct prosodic categories) and differences in degree (pointing to forms of grouping of instances of the same prosodic category).

In what specifically concerns European Portuguese, it is crucial to study the prosodic organization shown by other varieties to assess the general or specific character of the properties summarised in Table 1. The phonological phrase is especially interesting, given the absence of segmental, durational and tonal evidence that characterized its subtle manifestation in the prosody of Standard EP, when compared with the much stronger ways it is manifested in other languages (e.g. Nespor & Vogel 1986, Hayes & Lahiri 1991, Ghini 1993, among others).

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### 6.3. RHYTHM

#### 3. RHYTHM

##### 3.1. Notions of rhythm

##### 3.2. Different approaches to rhythm: between phonetics and phonology

##### 3.3. Rhythmic space: classes or a continuum?

##### 3.4. Analysing rhythm in production and perception: the case of Portuguese

##### 3.5. Correlations and explorations: phonology, lexicon, evolution of rhythm

Section 3 of the course program focuses on the study of rhythm. Different notions of rhythm are presented. The role of rhythm in the prosodic organization of language is highlighted, together with the various phenomena and properties that may contribute to the sensation of a given rhythm. Studies on the production and perception of rhythm in Portuguese are presented, within the larger context of cross-linguistic comparisons.

As mentioned in section 1 of the program, prosodic structure defines the prosodic heads or prominent elements, thus contributing to establishing the patterns of sequences of strong and weak elements. Additionally, prosodic domains govern the (non)application of rhythmic phenomena. Rhythm can be seen as resulting from the way prominences are organized in the speech chain. The heads of prosodic constituents contribute to such organization (Figure 1), from the stressed syllable of each prosodic word to the head of the intonational phrase, together with the properties of phonetic implementation of prominence (e.g., duration, intensity, F<sub>0</sub> shapes due to the presence of pitch accents). Rhythmic phenomena also contribute to such organization: these phenomena tend to implement sequences of alternating strong and weak elements, as in the case of stress clash resolution phenomena (see (2) above) or of the resolution of lapses, that is of long intervals of weak elements (11). Other types of phenomena that contribute to such organization are strengthening phenomena that ensure that heads are more prominent than non-heads – like the placement of the heavier element to the right edge of the phonological phrase or the intonational phrase (12), or the presence of weight restrictions that mark the distinction between stressed and unstressed syllables (even in languages where syllabic weight is not considered relevant for stress – (13) ). The crucial prosodic domain for the phenomena mentioned above is the intonational phrase (I), for both clashes and lapses are not solved if an I-boundary intervenes.

- (11)
- ```

      *
    *   *
  *   *   *
*   *   *   *   *
  
```
- (The asterisk in the third row, second column is circled)

[Gianni non ce lo da] I

- (12) a. ?\*[Maximiliano Zeca]  $\phi$   
 b. [Zeca Maximiliano]  $\phi$

- (13) Stressed syllable in capitals; heavy syllable in bold  
 a. canÇÃO, ÓRfãO  
 b. \*CRíticãO

Prominence or weight are realized by phonetic and phonological properties. In EP, duration is a crucial acoustic cue for word stress (Figure 7), as well as for I-prominence. The sonority of segments, defined both acoustically and articulatorily, contributes to weight (14), as well as the relative position of the head in a sequence (15a), or the size and phonological complexity of the elements within that sequence (15b).

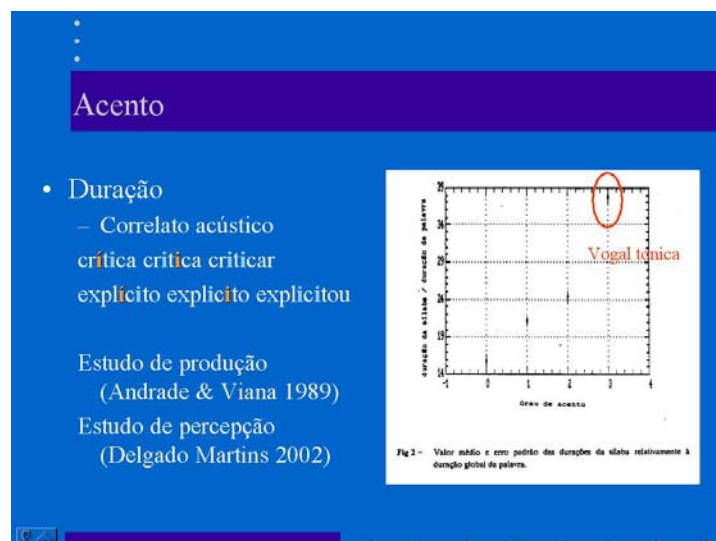


Figure 7. Syllable duration and word stress.

- (14) a. ping pong vs. \*pong ping  
 b. tic tac vs. \*tac tic
- (15) a. Stéfano e Marilú vs. ?Marilú e Stéfano  
 b. O João comprou, segundo me disseram, [água-pé] vs.  
 ?\*O João comprou, segundo me disseram, [água]  
 'John has bought, so they say, light wine/?\*water'

An important concept in the description of linguistic rhythm is isochrony, that is the sensation that rhythm is based on isochronous units. The traditional view of linguistic rhythm is based on the idea of isochrony, and classifies languages into one of three rhythmic groupings: syllable-timed languages, in which the timing regularity is based on syllables (like Italian); stress-timed languages, in which the timing regularity is based on interstress intervals (like English); and mora-timed languages, in which the timing regularity is based on morae (like Japanese). The initial proposal of rhythmic classes was based on linguistic intuition, and led to decades of phonetic studies. However, it is by now well-known that the physical basis of rhythmic distinctions as differences in the isochrony of the various linguistic units has been difficult to ascertain. Indeed, numerous phonetic studies have failed to confirm the hypothesis of isochronous units. In a different line of research, namely that of perception studies, it has been successfully shown that languages belonging to different rhythmic classes are perceptually distinct, whereas languages from the same class are not.

Within a different approach to linguistic rhythm, rhythmic distinctions among languages are seen as resulting from the presence/absence of particular phonological and phonetic properties in a given linguistic system. This approach led to a new trend in phonetic-phonology studies, in the search of acoustic correlates in the speech signal for the phonetic and phonological properties considered relevant for rhythm. Of the three major types of such properties initially proposed by Dauer (1983, 1987) – syllable structure, vowel reduction, and the relation between stress and prominence –, special attention has been given to the first two. The correlation found between these properties and rhythmic classes is given in (16).

- (16) a. Syllable structure complexity / variety
- + ←—————→ -  
 Stress-timed          Syllable-timed          Mora-timed
- b. Vowel reduction
- + ←—————→ -  
 Stress-timed          Syllable-timed          Mora-timed

The search for acoustic correlates of these properties, as a possible source of explanation for the rhythmic distinctions found in perception, has resulted in several rhythm measures with varying success (a critical review is provided in Arvaniti 2009). All of them take the duration of vocalic intervals (Vi) and consonantal intervals (Ci) as a starting point, and measure the variability of these intervals or the proportion of these intervals within a given domain. It seems to be clear that at least some of these measures succeed in capturing rhythmic differences; however, it also seems to be clear that the rhythmic space they define is not always formed by neat rhythmic classes, but by a kind of rhythmic continuum instead. The correlation between these measures and the properties in (16) is given in (17).

- (17) a. Syllable structure complexity / variety
- + ←—————→ -  
 +                      Variability of Ci                      -  
 +                      Proportion of de Vi                      -
- b. Vowel reduction
- + ←—————→ -  
 +                      Variability of Vi                      -

The rhythm of Português is analysed within this phonetic-phonological framework. In the traditional approach based on isochrony, Brazilian Portuguese (BP) was described as having a stress-timed, a syllable-timed, or a mixed rhythm, depending on the authors and studies. European Portuguese (EP), on the other hand, was described as being stress-timed. The new approach has provided different findings. Once the differences in speech rate are controlled, the rhythms of the two varieties stand out as acoustically different, on the basis of the Ci variability and Vi proportion measures<sup>4</sup>: EP shows mixed

<sup>4</sup> As in other studies, Vi variability does not provide robust results (e.g. Arvaniti 2009).

rhythm, both stress and syllable-timed, joining English and Dutch in one dimension and Italian and Spanish in the other; BP shows mixed rhythm between syllable and mora-timed (Figure 8). These results are congruent with the phonetic and phonological properties of the two varieties. If one takes the same phonological syllable structure, in EP the tendency is for the deletion of unstressed vowels yielding sequences of consonants, whereas in BP there are phenomena of syllable simplification like epenthesis or coda deletion; in EP there is overall vowel reduction in unstressed positions, whereas in BP vowel reduction is minimal (and pre-tonic); in EP, tonal events strengthen prominence, whereas in BP intonation and stress are more independent.

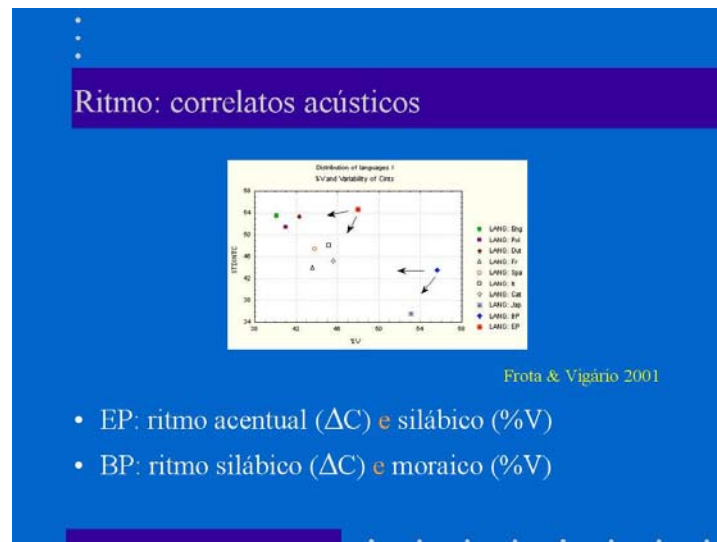


Figure 8. EP and BP in the rhythmic space defined by Ci variability and Vi proportion, together with the languages analysed in Ramus et al. 1999.

The identification of mixed languages raises (again) the question whether languages cluster into distinct rhythmic classes or scatter along a rhythmic continuum. Furthermore, the finding of a conflict between acoustic measures (each pointing to a different classification), raises the question of their relative weight in perception (in other words, of how mixed languages are perceived).

Perception studies have reported rhythm-based language discrimination, both by adults and infants, providing evidence that languages are perceptually grouped according to their rhythmic properties. The inclusion of Portuguese in the database of languages tested allows us to examine the status of an

acoustically mixed language. In the studies with Portuguese, the relevance of intonation to language discrimination was also assessed.

The results from the perception studies show that EP and Dutch are discriminated, like Spanish and Dutch, or BP and Dutch. However, in an experiment where the four languages/varieties are reduced to two possible choices by the subjects, EP and BP are not discriminated from each other, showing that the perceptual distance between EP and BP is smaller than the distance between EP and Dutch (Figure 9). When EP and BP are the only languages in the experiment, for the same two possible choices, discrimination is only obtained in the condition with intonation. In fact, the contribution of intonation to rhythmic discrimination is highly dependent on the languages, that is on the properties of the intonation systems. This contribution is crucial for EP and BP, but almost irrelevant for EP and Dutch.

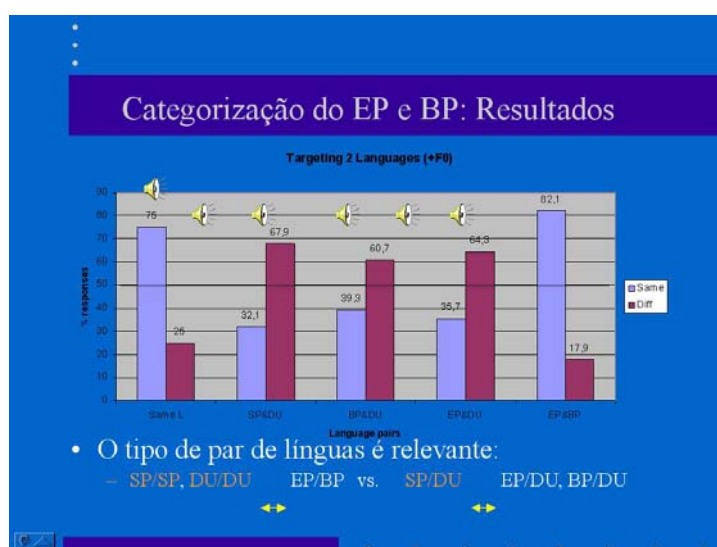


Figure 9. Perception of Portuguese rhythm (Frota, Vigário & Martins, 2002b). [ ⚙️ : D1 , EP1 , S1 , BP1 , D2 , EP2 , S2 , BP2 ]

The perceptual distinction between EP and Dutch suggests that the proportion of  $V_i$  is more salient than the variability of  $C_i$ . The non-discrimination between EP and BP (except in the condition with intonation) suggests a critical point in  $V_i$  proportion, pointing to a possible perception boundary close to the difference between the first two groupings of languages, that is to the stress-timed / syllable-timed difference (Figure 10).



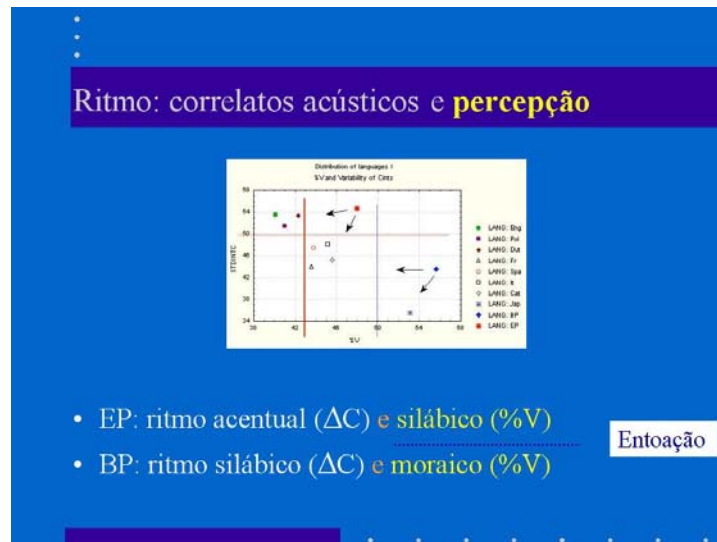


Figure 10. Rhythm: acoustic correlates and perception.

The study of Portuguese rhythm, both from the production and perception viewpoints, is used to illustrate experimental procedures common in the study of rhythm. On the production side, it illustrates how balanced and controlled corpora are constructed, as well as the application of acoustic segmentation criteria for the measurement of duration in the speech signal. On the perception side, it illustrates how stimuli are constructed by resorting to low-pass filtering and tonal flattening. It also illustrated the design of AX tasks and the way sensitivity in discrimination is measured ( $d'$ ).

The research presented and discussed in this section raises the following fundamental question for the understanding of rhythm in language: is rhythm a structuring principle in language, or is it an epiphenomenon? It seems certain that several linguistic properties (and not only the phonetic, phonological and prosodic properties mentioned above, but also some lexical and syntactic properties – see Mehler & Nespors 2004) are correlated with rhythmic differences thus suggesting an analysis in which the latter derive from the former. However, it is also clear that evidence in favour of a structuring principle, possibly anchored on general principles of perceptual organization, emerges frequently in language, with the grouping of stimuli into constituents characterized by alternating and repetitive patterns: for example, the sound made by a (old) clock is perceived with the prosodic structure (tic tac) (tic tac) (tic tac), but not (tic) (tac tic) (tac tic tac); and the segmentation of *note book*

*worm*, all else being equal, depends on the alternanting pattern generated by previous syllables, with L H L H L favouring (*note*) (*bookworm*) and H L H L HL favouring (*notebook*) (*worm*) (Dilley & McAuley 2008). Research is in progress that may bring new insights to the understanding of rhythm in language, through the analysis of typologically different languages with respect to the ways they implement prominence and prosodic structure, and through the study of the relation between the perceptual organization of linguistic and non-linguistic signals (e.g. Mehler, Nespors and colleagues; White and colleagues; Arvaniti, among others)

In the specific case of Portuguese, acoustic studies looking at other varieties in a methodologically comparable way are needed. These studies should be developed within an integrated view of prosodic structure, rhythm and intonation, that is taking into account prosodic domains and rhythmic and intonational properties. On the perception side, it would be crucial to directly test the pair {EP, Spanish} and the pair {BP, Spanish} to determine whether Ci variability plays any role in rhythmic discrimination. Another research area to be explored is that of the evolution of rhythm, where EP and BP are a good test case, and an experimental approach based on the correlations found between rhythmic properties and phonological and lexical properties may provide interesting results.

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## 6.4. INTONATION

### 4. INTONATION

- 4.1. Melody in language: tonal languages and intonational languages
- 4.2. Phonetics and phonology of intonation
- 4.3. Analysing intonation: the case of Portuguese
- 4.4. Intonational variation: varieties of Portuguese and Romance languages

Section 4 of the program focuses on the study of intonation. The observation that melodies play different roles in different languages leads to the notions of tonal language and intonational language. The basic instruments for the phonetic and phonological analysis of intonation are described, within the autosegmental and metrical framework of intonational analysis. The intonation of Portuguese is analysed from a cross-linguistic perspective, with emphasis on Romance languages.

In its linguistic dimension, the role of melody in language is characterized by a distinction between melodic configurations that determine

lexical meaning and morphological contrasts – as in tonal languages –, and melodic configurations that convey sentence-level or postlexical meanings – the only present in intonational languages. By intonation, we thus refer to the set of linguistic non-lexically defined pitch configurations. These pitch configurations are associated to phrasal-level meanings, such as differences among sentence types, pragmatic and discursive distinctions (like information structure ones). The phonological representation of intonation is a sequence of tonal categories. Its phonetic representation is the F0 contour. Intonation has a phonological organisation, according to which intonational features relate with independent features of the phonological organisation of speech established on the basis of prosodic structure (see Figure 3 above).

The tones in an intonation contour are either high (H) or low (L). These tones form two main types of tonal categories: pitch accents (T\*), which are tonal events associated with prominent elements in the segmental string (prosodic heads), and edge-related tones, linked to prosodic domain edges. Figure 11 illustrates both types: pitch accents are identified by an \*, whereas edge tones are identified with diacritics that signal the type/level of constituent they are linked to (in the example, % is used because the tonal string contains intonational phrase boundary tones).

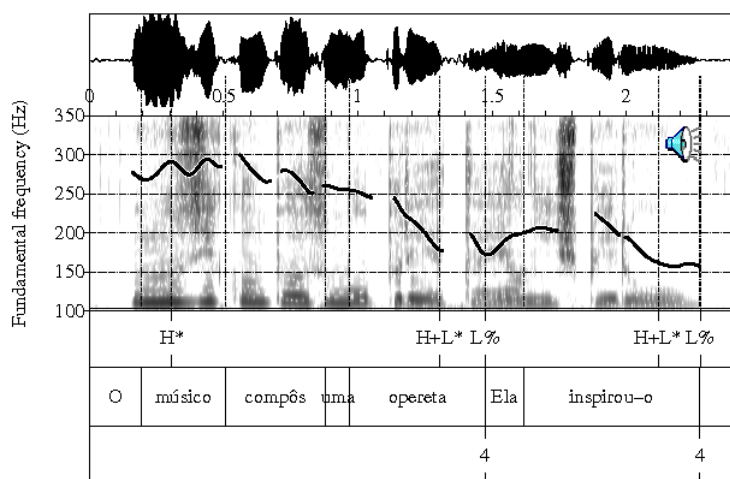
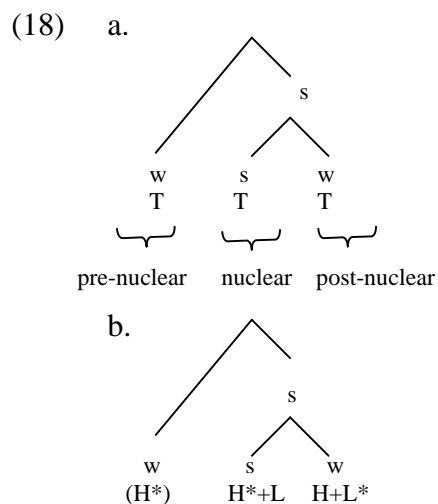


Figure 11. F0 contour of *O MÚsico compÔs uma opeREta. Ela inspiROU-o* 'The musician has composed an operetta. She inspired him', and respective phonological analysis (stressed syllables in capitals).

Tonal events may be simple or monotonal, like  $H^*$  and  $L\%$  in Figure 11, or complex, like  $H+L^*$  in Figure 11.

Another component of the phonological organization of intonation, besides the string of tonal categories, is prominence structure: within the domain of one intonational phrase, there is the nuclear accent (on the most prominent head), the pre-nuclear accent(s) (in case there are pre-nuclear heads) and the post-nuclear accent (on one post-nuclear head). The post-nuclear accent may only occur if the I-phrase head is not the rightmost element in the string (in EP, this would mean a case of marked prominence usually connected with prosodic focalization). This intonation structure is represented in (18a). Example (18b) shows the intonation structure of the sequence in Figure 12, with non-final prosodic focus. The phonetic reduction that characterizes the post-nuclear accent can be seen in Figure 12.



The relation between the phonological representation of intonation (the structured sequence of tonal categories) and the phonetic representation (the  $F_0$  contour) is given by the phonetic implementation of the tonal string. There are two main forms of phonetic implementation: interpolation between two tonal targets, and spreading of one tone until another tone is found (see Figure 13).

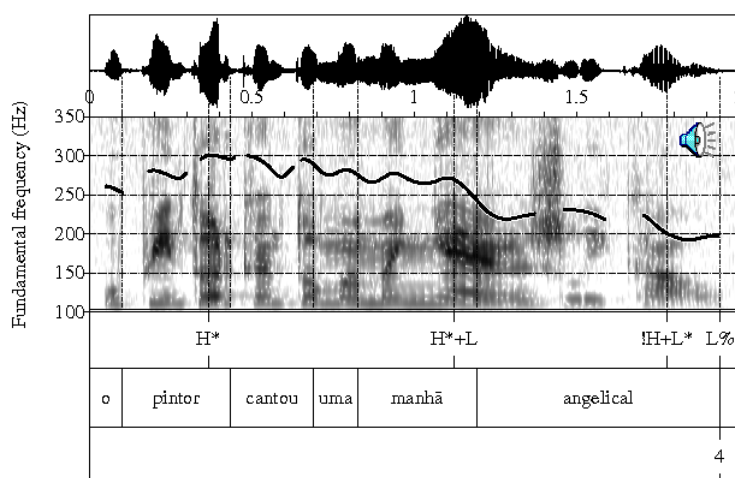


Figure 12. F0 contour of *o pinTOR canTOU uma maNHÃ angeliCAL* (stressed syllables in capitals) 'The artist sang an angelic morning', with focus on 'manhã' (uttered in response to the question *Was it an angelic night that the artist sang?*).

### Fonologia Entoacional

- Representação fonológica e representação fonética
  - interpolação H      H L H L L
  - espraiamento H L L H
  - associação tonal: tons e cabeças / tons e fronteiras
  - alinhamento tonal: coordenação fonética da realização do alvo tonal face à cadeia segmental (early, late)

CV. C'V. CV ]

L\* Hx

Figure 13. Relation between phonological and phonetic representation of intonation.

Together with the phonetic implementation by interpolation or spreading, tonal realization depends on the tonal reference lines established by prosodic constituents and on the position of the tone relative to other tones in the same constituent (see example (3) from section 1): a non-initial tone is realized at a lower level than the preceding tone (downstep); an initial tone is realized at a

higher level than the immediately preceding tones from the preceding constituent (reset); a final H boundary tone takes the reference line of the constituent it belongs to (upstep). In other words, phonetic height is relative and contextually determined.

On the temporal dimension, tonal categories and segmental string are synchronized on the basis of the phonological association of a given tonal event to a given prosodic position (head or edge), together with the phonetic coordination between tonal target and segment (alignment), as illustrated in Figure 13. Phonetic alignment may take the form of early or late alignment, depending on various factors such as the distance to prosodic boundaries or to other tonal events, or even the internal structure of a given tonal event. Figure 11 shows an example of the typical late alignment in EP of the starred tone in the pitch accent H+L\*, with respect to the stressed syllable.

Besides phonetic alignment, synchronization between tonal categories and segmental string is also characterized by tonal accommodation phenomena. This type of phenomena is usually purely tonal: certain languages favour tonal compression in presence of a short segmental string (as it is the case of English); others favour tonal truncation in a similar context (as it is the case of Hungarian or Palermo Italian). In EP, tonal accommodation seems to be achieved at the expense of the segmental string, that is the segmental string is extended to accommodate the tonal sequence, either by means of lengthening or epenthesis. The latter strategy is illustrated in Figure 14.

Table 2 summarizes the crucial dimensions of intonational analysis (for intonational languages, like English, Italian, or Portuguese). The first dimension – the relation between intonational structure and prosodic structure – was already explored in previous sections of the program. The work on the intonation of EP developed along the course deals mainly with the second and third dimensions, which, together with the first, form the core of the intonational phonology of a language.

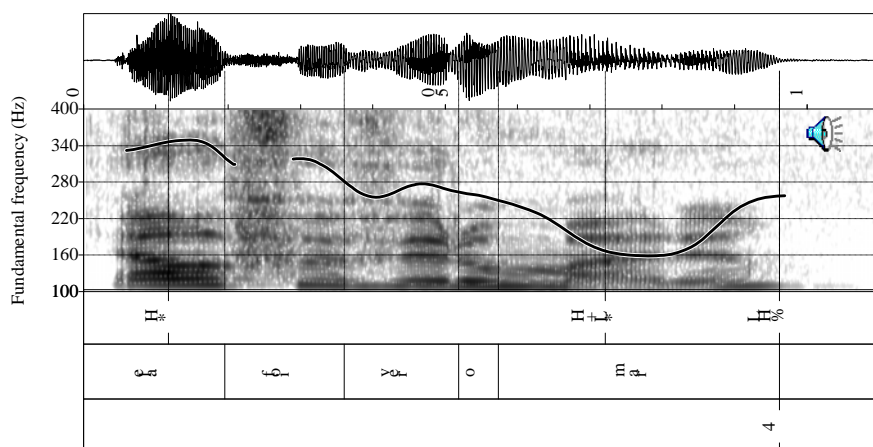


Figure 14. F0 contour of *Ela FOI VER o MAR?* 'Has she gone to see the sea?' (stressed syllables in capitals). The boundary rise is realized in the epenthetic vowel.

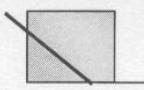
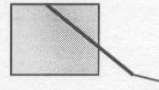

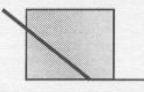
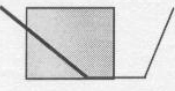
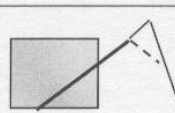
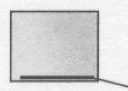


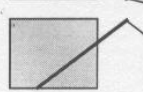
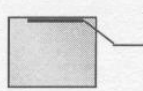
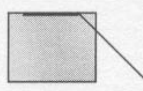
Table 2. Dimensions for intonational analysis.

|                                                      |                                                                          |
|------------------------------------------------------|--------------------------------------------------------------------------|
| <i>Prosodic structure</i>                            | Constituents (prominence and edges)                                      |
| <i>Intonational lexicon</i>                          | Inventory of pitch accents and edge tones, and respective meanings       |
| <i>Relevant domain for pitch accent distribution</i> | Prosodic constituent                                                     |
| <i>Distributional restrictions</i>                   | Constraints on the occurrence/combination of tonal events                |
| <i>Phonetic implementation</i>                       | Spreading/interpolation, alignment, reference lines, tonal accommodation |

Hands-on sessions of intonational analysis are run with EP materials. The general goal is to characterize the main sentence types and some pragmatic-discursive distinctions with respect to the intonational lexicon. A step-by-step procedure is followed. In the first step, the analysis focuses on nuclear contours and Table 3 is used as a starting point. The listening of the sequence together with the drawing of the F0 contour are the basis for achieving a phonological tonal transcription. In a second step, the whole sequence is analysed, including the pre-nuclear stretch and issues of prosodic and intonational phrasing.



Table 3. EP tunes: labels, realization of the nuclear contour, usage (adapted from Frota, in press).

| Labels            | Realization                                                                         | Context/Meaning                        |
|-------------------|-------------------------------------------------------------------------------------|----------------------------------------|
| (H) H+L* L%       |    | Neutral declarative                    |
| (H) H*+L L%       |    | Topic phrase                           |
| (H) H*+L !H+L* L% |                                                                                     | Focused declarative<br>Early focus     |
| L*+H H%           |    | Continuation<br>Parenthetical          |
| (H) H+L* L%       |    | Wh-question                            |
| (H) H+L* LH%      |   | Neutral yes-no question                |
| (H) L*+H HL%      |  | Focused yes-no question                |
| (H) L*+H LH%      |                                                                                     | Early focus (dashed line)              |
| H* L* L%          |  | Request (multiword)                    |
| %H L* L%          |  | Request (one word)                     |
| (H) H*+L L%       |  | Command (late focus)                   |
| H*+L (L*) L%      |                                                                                     | Early focus                            |
| L*+H (L*) L%      |  | Early focus                            |
| (L+)H* !H%        |  | Vocative chant (greeting)              |
| (L+)H* L%         |  | Low vocative chant<br>(insisting call) |

The demonstration that tonal events, in EP as in other languages, may behave as morphemes encoding semantic/pragmatic information is carried out on the basis of two examples: the contrast between a declarative and a yes-no question (where the boundary tone bears the distinction – Figures 15a-15b); the contrast between a (neutral) yes-no question and a focused yes-no question (where the nuclear accent bears the distinction – Figures 15b and 16).

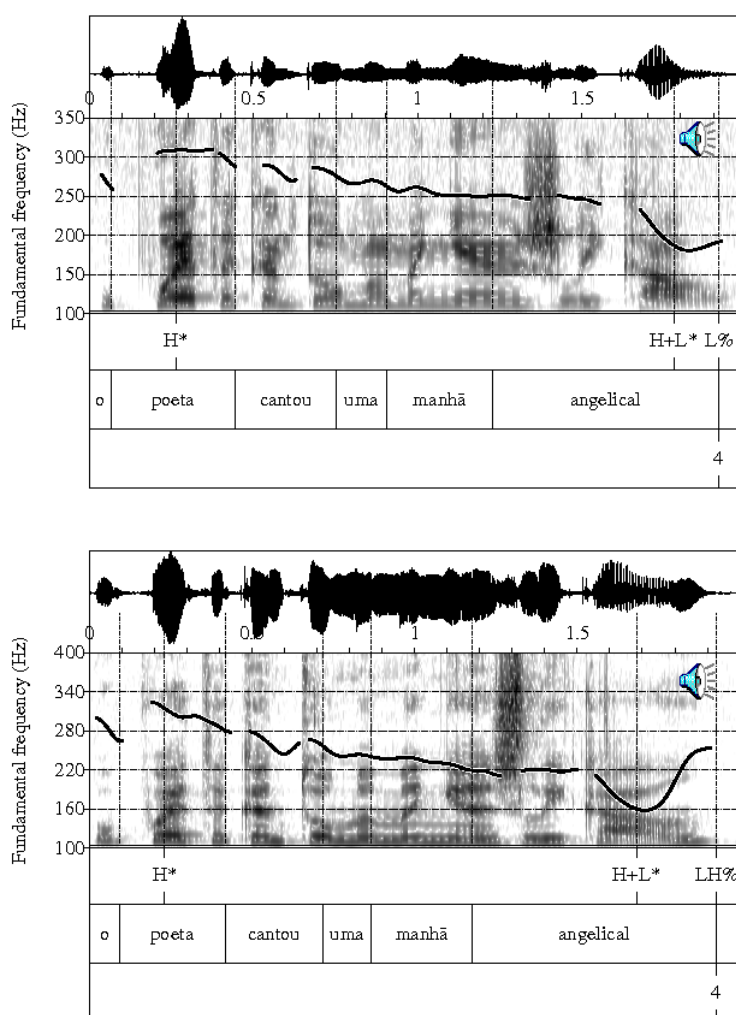


Figure 15. F0 contour of *o POEta canTOU uma maNHÃ angeliCAL* 'The poet sang an angelic morning' (stressed syllables in capitals): (a) produced as a neutral declarative; (b) produced as a yes-no question.

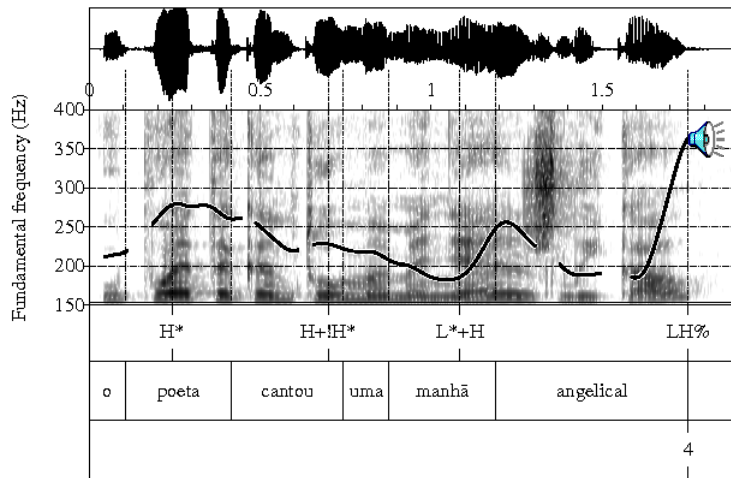


Figure 16. F0 contour of *o POEta canTOU uma maNHÃ angeliCAL* 'The poet sang an angelic morning', produced with the focus on *manhã* (as uttered in the context 'I've read that poem but I don't remember what part of the day the poet describes as angelic').

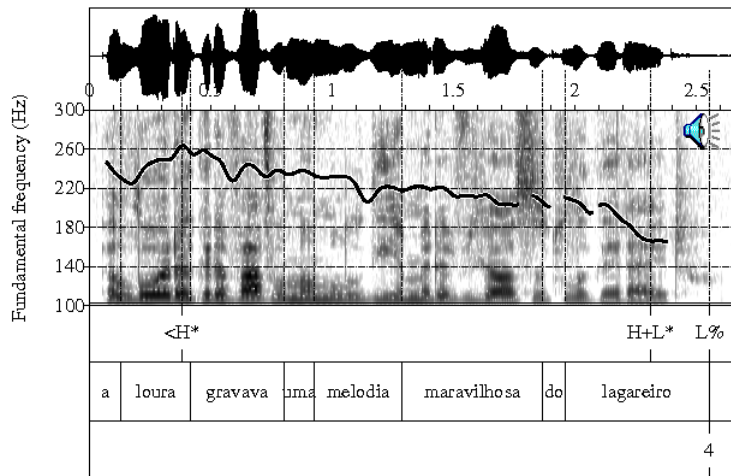


Figure 17. F0 contour of *a LOUra graVAva uma meloDIA maraviLHOsa do lagareiro* 'The blond girl recorded a wonderful song from the olive-pressman', produced as a neutral declarative.

The analysis of the whole utterance, pré-nuclear stretch included, shows that pitch contours in EP are formed by the nuclear pitch accent plus an I-final

boundary tone, with the addition of an initial tonal event within the same intonational phrase (Figure 17). In other words, the relevant domain for pitch accent distribution in EP is the intonational phrase: I-internal prosodic words, even if heads of phonological phrases (as *gravava* and *maravilhosa*, in Figure 17), do not have to be pitch accented.

The dimensions in Table 2 above are naturally dimensions of variation among languages and language varieties, and thus factors to take into account for a prosodic typology. The findings on variation in intonational phrasing among Romance languages, already mentioned in section 2 of the program (see Figure 6), illustrate the relation between prosodic and intonational structure as a relevant dimension of variation. Table 4 shows another instance of variation: the distribution of nuclear pitch accent types in the first intonational constituent of an utterance, in several Romance languages. The results cluster languages into two groups, depending on the predominance of rising or falling accents.

Table 4. Distribution of nuclear pitch accent types (%) per language and speaker (Frota et al. 2007).

|     |    | L+H* | L*+H | H+L* | L* |
|-----|----|------|------|------|----|
| Cat | NM | 97   | 0    | 3    | 0  |
|     | PG | 100  | 0    | 0    | 0  |
| Sp  | LM | 27   | 73   | 0    | 0  |
|     | MR | 5    | 95   | 0    | 0  |
| SEP | AG | 0    | 57   | 43   | 0  |
|     | MC | 0    | 11   | 89   | 0  |
| NEP | MI | 19   | 57   | 7    | 17 |
|     | MS | 0    | 0    | 14   | 86 |
| It  | LC | 47   | 0    | 0    | 53 |
|     | LD | 41   | 0    | 59   | 0  |

Systemic differences, where distinct tonal events are used in the same contexts, are another example of intonational variation across languages/varieties. The contrast between yes-no questions in the Standard variety of EP and in the Northern variety spoken in Braga, or in the Southern variety spoken in Castro Verde (Alentejo) is a good example: H+L\* is the nuclear accent in the Standard, whereas L\* is the nuclear accent in the other two varieties; the boundary tone is LH% in the Standard, L% in the Southern variety, whereas the Northern variety shows a mixed behaviour. The contrast is illustrated in Figure 14 above (Standard variety) and Figure 18 (Southern variety).

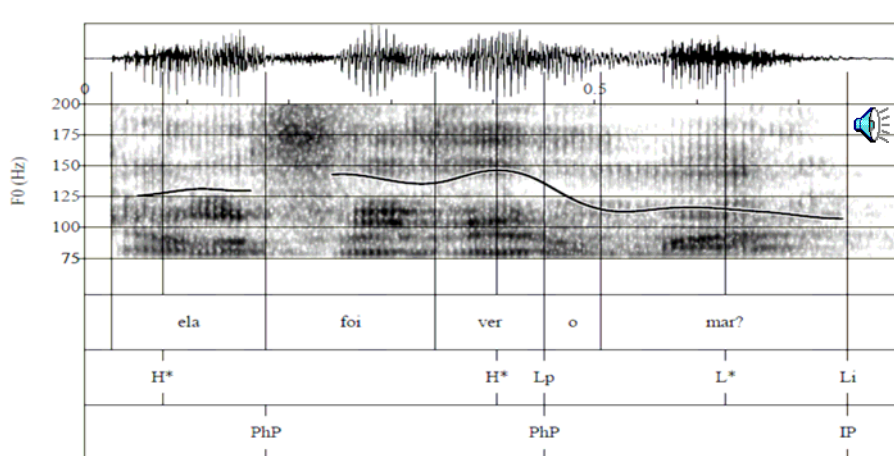


Figure 18. F0 contour of *Ela FOI VER o MAR?* 'Has she gone to see the sea?', uttered by a Southern variety speaker (Castro Verde, Alentejo – Cruz & Frota 2010).

Besides differences in the intonational lexicon used, the relevant domain for pitch accent distribution may also vary across languages/varieties. Contrary to Standard EP, which is characterized by a sparse pitch accent distribution given that the relevant domain is the I-phrase, other Romance languages show a richer distribution of pitch accents suggesting that the relevant domain is a lower prosodic constituent. That is also the case in other varieties of EP, such as the Northern variety (Braga): see the difference between the contours in Figure 17 and Figure 19.

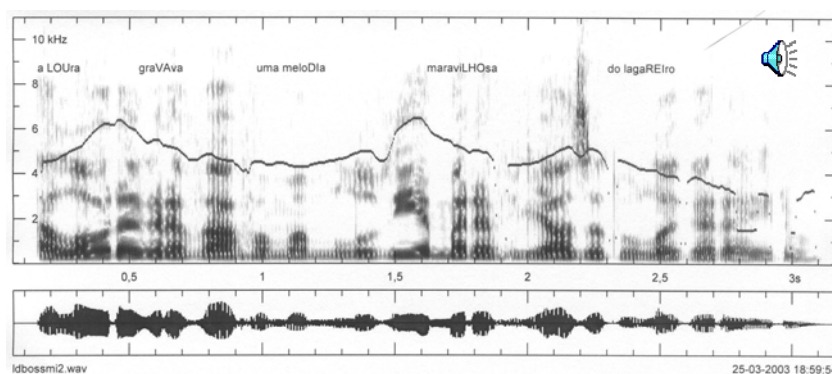


Figure 19. F0 contour of *a LOUra graVAva uma meloDia maraviLHOsa do lagaREiro* 'The blond girl recorded a wonderful song from the olive-pressman', uttered by a Northern variety speaker (Braga).

Despite the considerable development in methodologically comparable research on many different languages that the Autosegmental-Metrical approach has provided (e.g. Jun 2005, in press), fundamental questions in intonational phonology remain open to discussion (see, for example, Ladd 1996/2008, and Gussenhoven 2004). One of such questions concerns the nature of intonation and the definition of the phonological categories of intonation. Pitch contours contain both discrete elements (the linguistic part) and gradient elements (the paralinguistic part), thus making the definition of intonational categories a difficult task. Furthermore, the division of labour between what pertains to phonetic implementation and to phonological representation of intonation categories is not always clear. Take the case of tonal alignment. The temporal relation between tonal targets and segmental string may be determined by various factors (like the distance to prosodic boundaries, or the presence/absence of other tonal events), and thus the same tonal category may show different alignment to the segmental string. However, some languages explore alignment contrasts to convey different meanings, showing that they have grammaticalized alignment by incorporating it into the distinctions between tonal categories. The study of which pitch differences may be phonologized in a specific language requires experimental research addressing the relation between variation in phonetic form and assignment of intonational meaning. Semantically motivated perception tasks, together with on-line processing studies, have provided promising findings (Sudhoff et al. 2006).

Experimental studies on the definition of the tonal categories of Portuguese intonation are still scarce (see the work by Falé & Faria, and Frota). Research along this line, as well as studies on intonation variation within Portuguese which relate production and perception, are crucial to the understanding of the intonational system of Portuguese, and a contribution to the understanding of prosodic typology.

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## 6.5. PROSODY AND MEANING

### 5. PROSODY AND MEANING

#### 5.1. Prosody and language processing by adult speakers

#### 5.2. Prosody and language processing by babies and children

Section 5 of the course program is devoted to the contribution of prosody to meaning, from the perspective of language processing. The focus is on the study of disambiguation and the role of prosody in lexical and syntactic processing. Experimental work examining the segmentation of the speech signal into words and phrases, both by adults and children, is presented and discussed.

One of the central questions in language studies is how the speech signal is segmented into word and phrase-sized units. A way to address the problem is to examine the processing of ambiguous utterances or of utterances with temporary ambiguities. Studies of the production of utterances with structural ambiguities, in different languages, have shown that such utterances are not always disambiguated in natural renditions, if the speakers are not explicitly confronted with the ambiguity. These findings show that prosodic disambiguation is not obligatory. However, when disambiguation does occur, the prosody produced and the interpretation intended are coherent in the sense that speakers use specific prosodic configurations that distinguish between the contrasting meanings. An example of prosodic disambiguation is given in Figure 20. In EP, the disambiguation of structurally ambiguous utterances is generally obtained by means I-phrase boundaries, which block the interpretation based on a structural connection between the phrases adjacent to the prosodic boundary. In the example in Figure 20, the I-phrase boundary after *populações* (19b) determines that only the interpretation that *as populações moveram-se do interior para o litoral* is possible, and the interpretation that *as populações que são do interior foram para o litoral* is blocked. The latter interpretation is only available when there is no I-phrase boundary after *populações*, as in (19a).



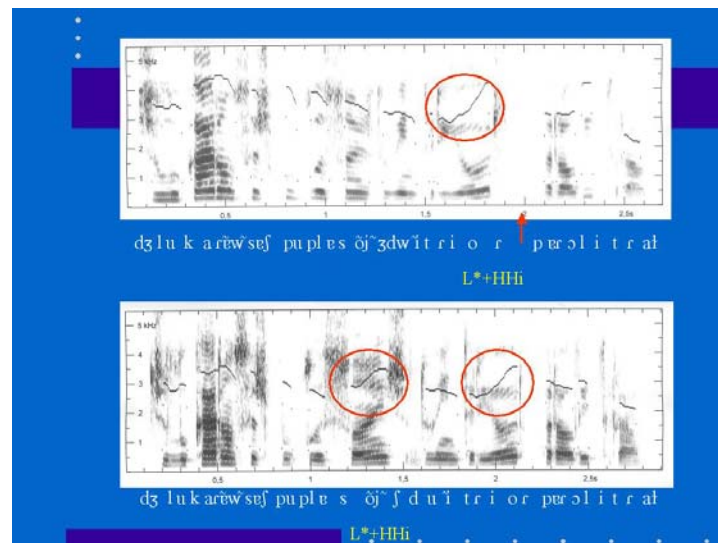


Figure 20. Prosodic disambiguation of the structurally ambiguous utterance *Deslocaram-se as populações do interior para o litoral* [they-moved the people from-the inland to the coast] (Vigário 2003).

- (19) a. [deslocaram-se [as populações [do interior]PP]NP [para o litoral]PP]VP  
 [ [deslocaram-se]φ [as populações]φ [do interior]φ [para o litoral]φ]I  
 (The people that were moved are from the inland)
- b. [deslocaram-se [as populações]NP [do interior]PP [para o litoral]PP]VP  
 [[deslocaram-se]φ [as populações]φ]I [[do interior]φ [para o litoral]φ]I  
 (The people were moved from the inland to the coast)

The use of an I-level boundary, and not a lower level boundary or other prosodic feature such as the distribution of pitch accents, is motivated grammatically. Constituents grouped within the same I-phrase bear a head-complement or head-modifier relation, which is not directly available across Is (see section 2 of the program). The optional presence of the I-boundary is also explained by the prosodic grammar: the I-boundary is not a direct result from the syntax-phonology mapping, since in (19) all constituents are within the domain of the same root sentence, but results instead from the promotion of a φ-level boundary for the purposes of prosodic disambiguation.

A classical case of structural ambiguity is relative clause (RC) attachment, whereby the RC may show local or non-local attachment (Figure 21). Structures of the type NP1 NP2 RC have been studied in different languages and resorting to different experimental paradigms. The results

obtained so far show that the preference for local or non-local attachment seems to vary across languages, even in the case of silent reading where speakers project their implicit prosody. Within the same language, results may depend on the method used (e.g. off-line or on-line studies). Moreover, studies of RC attachment have highlighted the important role played by prosodic factors, such as the size of the phrases: long phrases tend to trigger the presence of a prosodic boundary, which in turn affects the possibilities of constituent grouping.

**Desambiguação prosódica: Ligação de RC**

- Um caso clássico de ambiguidade sintáctica  
RC: *the servant of the actress who was in the balcony*
- Preferência pela ligação baixa ou alta varia entre as línguas (mesmo em leitura silenciosa) >> Prosódia (prosódia implícita)

|                  |                                                |
|------------------|------------------------------------------------|
| Inglês: Baixa    | Que diferenças prosódicas?                     |
| Neerlandês: Alta |                                                |
| Francês: Alta    | Resultados dependem da metodologia...          |
| Espanhol: Alta   |                                                |
| Galego: Alta     |                                                |
| Italiano: Alta   |                                                |
| Romeno: Baixa    | Efeitos de tamanho (RC, NP1, NP2) >> prosódia! |
| Mandarim: Baixa  |                                                |
| Japonês: Baixa   |                                                |
| PB: Alta         |                                                |
| PE: Alta         |                                                |

Figure 21. Relative clause attachment and prosody.

The reason behind the different preferences across languages (especially in off-line studies) is still an open question in this line of research. Both the syntax of the language, as well as its prosodic system, and the way they interact are strong candidates to provide a satisfactory answer. However, languages like English, Japanese, and Mandarin, with important syntactic differences (for example, English has the order NP1 NP2 RC, whereas Mandarin has the order RC NP2 NP1) and different prosodic systems (English is an intonational language, Japanese is a language in which pitch accents are lexically determined, and Mandarin is a tonal language), show the same preference for low attachment. On the other hand, most Romance languages, despite their prosodic differences (e.g. in the relevant domain for pitch accent distribution, in the ways the phonological phrase is signaled, or even in the way prominence is implemented), show a preference for high attachment. To illuminate the

understanding of the interpretation of these structures, experimental studies are needed where both syntactic and prosodic properties are controlled for.

The study of utterances with temporary ambiguities has shown that prosody plays a crucial role in language processing. Prosodic cues are known to constrain both lexical access and syntactic analysis **before** other disambiguating elements occur. In Figure 22, a possible representation of the role of prosody in lexical access is presented, as it has been assumed in various studies.

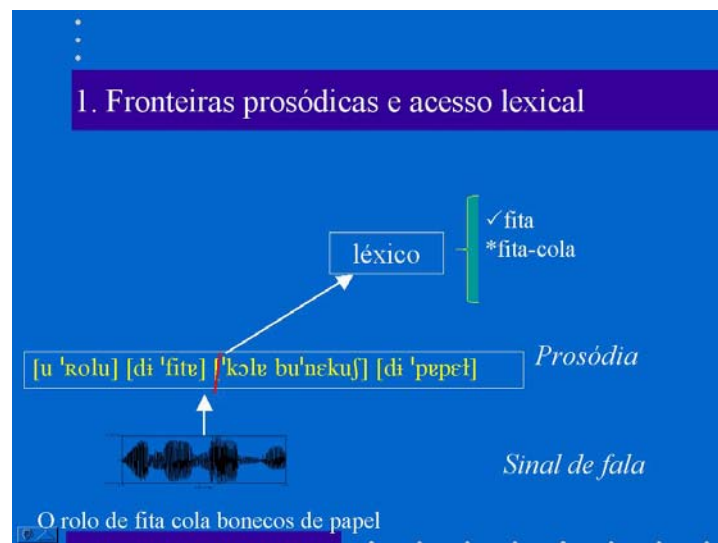






Figure 22. Prosodic boundaries and lexical access.

In local lexical ambiguity cases, as those in (20), the absence of a prosodic boundary above the word level (20a) leads to delays in processing when compared to a similar non-ambiguous case. By contrast, in the presence of such a prosodic boundary (20b) lexical recognition in the ambiguous and non-ambiguous sequence happens in similar timing (Christophe et al. 2004).



- (20) a. [un *chat grincheux*]ϕ {chat, chagrin} ≠ [un chat *drogue*]ϕ {chat}  
 b. [le gros *chat*]ϕ [*grimpait*...] = [le gros chat]ϕ [*dressait*...]

Similarly, in cases such as (21), the presence of a ϕ-boundary disambiguates between the possible lexical candidates, but the presence of a lower level boundary, as in (22), is not sufficient for disambiguation (Frota, Severino & Vigário 2009). These findings suggest that lexical access is processed in the domain of a phonological phrase.

- (21)  a. [o rolo de *fita cola*]φ [ficou... 'tape'  
 b. [o rolo de *fita*]φ [*cola*]φ [figuras... 'stripe sticks'
- (22)  a. [para quem *discorrer*]φ [sobre este tema... '(to) reason'  
 b. [para quem *diz correr*]φ [dez quilómetros... '(to) say (to) run'

The role of prosody in lexical access is illustrated by studies using several experimental paradigms, like word-monitoring tasks, phoneme detection tasks, or completion tasks.

Figure 23 depicts a possible representation of the role of prosody in syntactic processing. Utterances with local ambiguities but different prosodic structures, produced by speakers unaware of the ambiguity, tend to be successfully disambiguated by listeners. The prosodic properties behind disambiguation, however, may differ across languages: for example, in French a phonological phrase boundary seems sufficient to disambiguate between sequences of prosodic words (Milotte et al. 2007), whereas in EP an intonational phrase boundary seems to be needed (Frota, Severino & Vigário 2009). The examples in (23) and (24) respectively illustrate the two cases.

- (23) a. le petit chien]φ *mord* la laisse...  
 b. le petit chien *mort*]φ sera enterré...
- (24)  a. uma vez chegado *o professor*]I começaram...  
 b. uma vez chegado]I *o professor* começou...

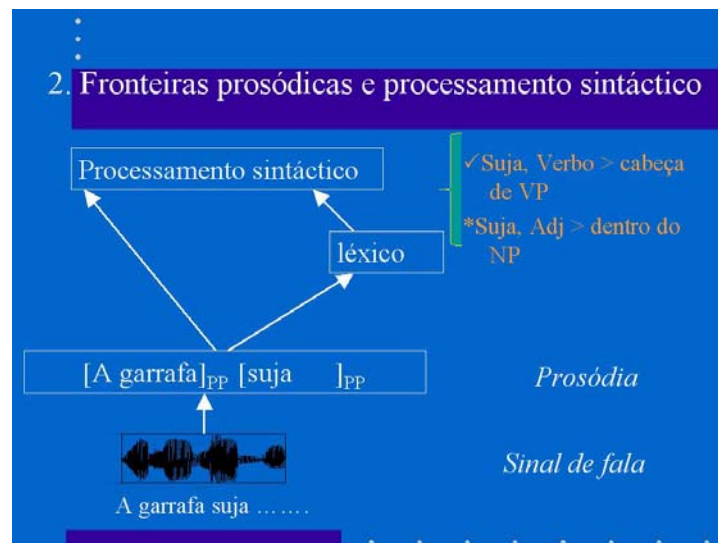


Figure 23. Prosodic boundaries and syntactic processing.

Such differences between languages call not only for a detailed examination of the prosodic properties of the input (French is clearly different from EP with respect to the prosodic cues for the phonological phrase – see sections 2 and 4 of the program), but also for cross-linguistic studies using comparable methodologies.

The role of prosody in syntactic processing is illustrated by studies using several off-line and on-line experimental paradigms, such as completion tasks, word-detection tasks and eye-tracking.

The use of prosodic cues for different types of linguistic units and structures is not exclusive of adult speakers. A bulk of work has shown that the input offers several kinds of cues (phonetic, prosodic, statistic) to word boundaries, word categories, different aspects of syntactic structure, and that infants and children explore these cues in language acquisition and development. The role of prosody in this process seems to be crucial (Morgan & Demuth 1996, Höhle 2009). Illustrative cases of the use of prosodic cues by babies and young children are presented, both for lexical access and syntactic processing.

Prosody helps in the segmentation of the speech signal into words. The role played by a phonological phrase boundary in cases of local lexical ambiguity is examined through the performance of English and French babies (respectively, Gout et al. 2004 and Millotte et al. in press). Using the Head-turn

Preference Procedure, babies listen to stimuli such as those in (25). The results show that by 10 months English babies already distinguish between monosyllabic and dissyllabic words, whereas French babies are only able to do it by 16 months of age. These findings confirm that prosodic information is computed very early on and is used as a cue in lexical acquisition. On the other hand, these findings also show differences between languages (like in the adult studies). The fact that the cues for word segmentation may be stronger in English than in French (especially due to prominence relations between syllables and the dominant stress pattern – see section 3 of the program) suggests that input differences can constrain the pace of language development.

- (25) a. The church with the most *paper* spires is heavenly  
           The man with the least *pay*]ϕ *perspires* constantly  
 b. La rangée de *balcons* fait face au cloître du monastère  
       La grande salle de *bal*]ϕ *confère* un air solennel au château

The relevance of prosody for the segmentation of the speech signal in cases of lexical ambiguity was also studied with Korean children between 2 and 5 years of age (Choi & Mazuka 2003). In utterances like (26), the placement of a prosodic boundary after or before *ka* is crucial for lexical segmentation. Children look at two different pictures and are asked to choose the picture that matches with the sound stimulus. The results show that children are able to correctly identify the lexical items, and their behaviour is not significantly different from the behaviour of adults.

- (26) a. K<sup>h</sup>ip<sup>h</sup>er *ka* ] *pang* e           tiləgayo           'Kipper enters (a) room'  
           Kipper-NOM quarto-LOC entra  
 b. K<sup>h</sup>ip<sup>h</sup>er] *kapang* e           tiləgayo           'Kipper enters (a) bag'  
           Kipper sacco-LOC           entra

In the same study, the use of prosodic cues in cases of structural ambiguity was also tested. In (27), the presence or absence of a prosodic boundary after *kirin* respectively assigns an interpretation of this element as the subject of the sentence or as part of the object. The prosodic cues that signal this boundary are the same as those that characterize the lexical ambiguity reported



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## 6.6. PROSODY AND LANGUAGE ACQUISITION

### 6. PROSODY AND LANGUAGE ACQUISITION

#### 6.1. Rhythm and language acquisition

#### 6.2. Acquisition of intonation

#### 6.3. Prosodic development

The sixth and final section of the program focuses on the contribution of prosody to the acquisition of several linguistic units and structures, as well as on the description of prosodic development. As is the other sections, experimental research is highlighted and special reference is made to studies on Portuguese.

There is a vast literature showing early sensitivity to prosodic properties and suggesting that infants are equipped with an input processing mechanism initially tuned to prosodic information (e.g. Morgan 1986, Morgan & Demuth 1996, Jusczyk 1997, Höhle 2009). Prosodic cues associated with properties such as stress, prominence and prosodic boundaries, rhythm and intonation, help the infant to segment the speech signal and may also contribute to establish linguistic categories.<sup>5</sup> This process became known as prosodic bootstrapping. The prosodic bootstrapping approach is one of the research approaches that contributes to the understanding of language acquisition (Figure 24).

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<sup>5</sup> See also section 5 of the program for an illustration of how prosodic properties help in the segmentation of the input.



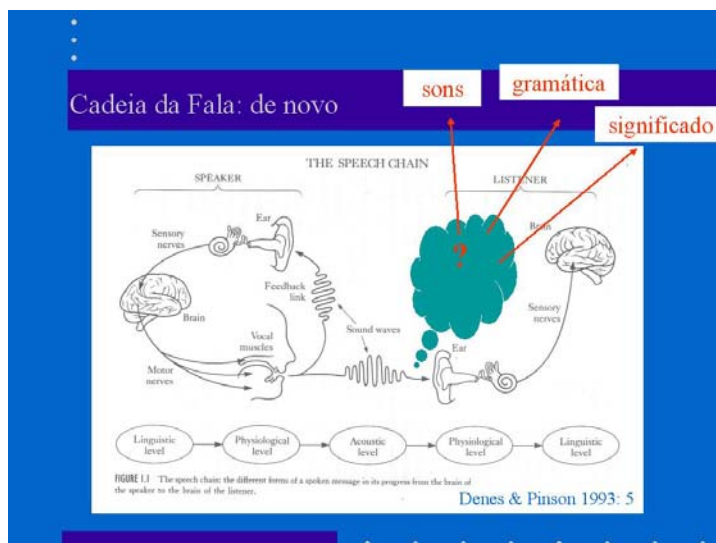


Figure 24. From signal to grammar.

Rhythmic prosodic cues have been the focus of much investigation. It is important to recall that various factors contribute to the sensation of rhythm, like pitch accent and prominence distribution, the way prominence is acoustically realized, or the patterns of segmental combination between consonants and vowels (see section 3 of the program). Nazzi et al. (1998) have shown that newborns are able to discriminate languages that belong to different rhythmic classes, but not languages that belong to the same class. In (28), a summary of findings in rhythmic discrimination studies with babies is presented.

| (28) | Rhythmic type                   | Language                           | Discrimination |
|------|---------------------------------|------------------------------------|----------------|
|      | Stress-timed / Syllable-timed   | English/Italian                    | √              |
|      |                                 | English/Spanish                    | √              |
|      | Stress-timed / Mora-timed       | Russian/French                     | √              |
|      |                                 | English +Dutch/<br>Italian+Spanish | √              |
|      |                                 | English/Japanese                   | √              |
|      | Stress-timed / Stress-timed     | Dutch/Japanese                     | √              |
|      |                                 | English/Dutch                      | X              |
|      | Syllable-timed / Syllable-timed | Spanish/Catalan                    | X              |
|      | Stress+Syll / Stress+Syll       | English+Italian/<br>Dutch+Spanish  | X              |

These results are strong empirical evidence that infants are equipped with perceptual devices that are especially sensitive to the rhythmic properties of the speech signal, and that allow for the identification of those properties.

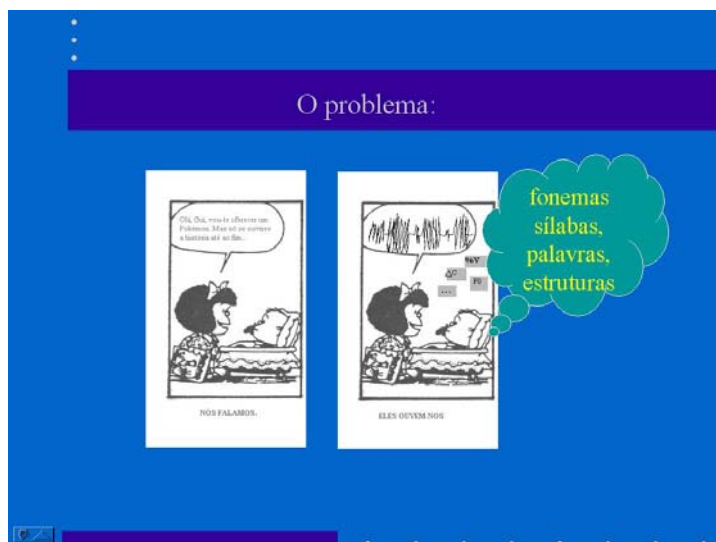


Figure 25. From signal to grammar: the role of rhythmic properties.

The relation between rhythmic properties and linguistic units has been explored in bootstrapping approaches (Figure 25). It has been proposed, for example, that rhythmic cues are on the basis of the prosodic bootstrapping of word order, word segmentation and the categorization of words, or of the types of syllabic repertoire (Nespor et al. 1996, Christophe et al. 2003; Jusczyk et al. 1999, Nazzi et al. 2006, Christophe et al. 2008; Mehler & Nespor 2002, Vigário et al. 2003).

The correlation found in language between prominence placement at the phonological phrase level and the order of heads and complements in syntax (see section 2 of the program) allows the association of the rhythmic pattern in (29a) with the order head/complement and of the rhythmic pattern in (29b) with the order complement/head. Experimental research has already shown that babies have the necessary perceptual abilities to compute these rhythmic cues, since they discriminate between segmental identical but prosodically different speech signals with regard to the placement of  $\phi$ -level prominence (Christophe et al. 2003).

- (29) a. [ ... (ws)φ (ws)φ (ws)φ ... ]I  
 b. [ ... (sw)φ (sw)φ (sw)φ ... ]I

Rhythmic properties in language are also correlated with prominence patterns at the lexical level, and word size. In stress-timed languages, like English, Dutch or German, the trochaic pattern (sw) dominates, contrary to what happens in French or EP.<sup>6</sup> Moreover, stress-timed languages typically have shorter words, whereas syllable-timed and mora-timed languages have longer words. These correlations are the basis for the expectations in the segmentation of the speech signal presented in (30): an initial segmentation based on stress, or rather on the trochaic binary foot (and with a tendency for shorter words) in stress-timed languages; an initial segmentation based on the syllable (and later with a tendency for longer words) in syllable-timed languages. Experimental research has indeed shown that English, Dutch and German infants are able to early segment trochaic words (but not iambic words), while French infants fail to segment disyllabic words and start by only recognizing monosyllables (Höhle 2009).

- (30) a. Stress-timed: [ x x (x<sub>S</sub> x<sub>W</sub>) x x ] trochaic pattern >> shorter words  
 b. Syllable-timed: [ x x (x) x x x ] syllable >> longer words

Function words are usually very frequent in language use, have a monosyllabic shape, no stress, and are located at the edges of prosodic phrases (namely of phonological and intonational phrases). It is conceivable that babies are able to extract these regularities, and compile a list of the most frequent of these elements which will be identified as function words when they occur at the edges of prosodic phrases. Experimental work has shown that babies are already able to identify word categories slightly after 1 year of age (Christophe et al. 2008).

Rhythmic properties are also correlated with the type of syllabic repertoire (see section 3 of the program). Stress-timed languages typically have

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<sup>6</sup> According to Cutler & Carter (1987), about 96% of lexical words in English start by the stressed syllable; 80% of lexical words are monosyllables. In EP, only 25% of lexical words start by the stressed syllable; 71% of lexical words have 3 or more syllables (type frequency, obtained over a section of FrePOP – Frota et al. 2010).

vast syllabic repertoires, with many types and complex syllables. By contrast, syllable-timed languages tend to have smaller repertoires, with less types and less complex syllables (Table 5). This correlation allows rhythm to play a role in the definition of the type of syllabic repertoire a language has. The type of syllabic repertoire, in turn, is also correlated with word size, and thus further contributes to the segmentation strategies in (30): complex syllabic systems allow for more diversity with less syllables, and thus promote smaller words; simple syllabic systems require more syllables to realize lexical contrasts, and thus promote longer words (Mehler & Nespor 2002).

Table 5. Some properties of complex and simple syllabic systems (Vigário et al. 2003).

| Syllable types       | English                                  | Dutch                                     | Spanish                         | French                           | EP                                       |
|----------------------|------------------------------------------|-------------------------------------------|---------------------------------|----------------------------------|------------------------------------------|
| Number               | 16                                       | 19                                        | 9                               | -                                | 6                                        |
| Most frequent (%)    | CV 34<br>CVC 30<br>VC 15<br>V 8<br>CVCC6 | CV 36<br>CVC 32<br>VC 15<br>CVCC 6<br>V 2 | CV 58<br>CVC 22<br>CCV 6<br>V 6 | CV 56<br>CVC 19<br>V 10<br>CCV 7 | CV 65<br>CVC 16<br>V 11<br>CCV 5<br>VC 3 |
| Closed syllables (%) | 56                                       | 59                                        | 30                              | 26                               | 19                                       |
| CC(C) (%)            | ---                                      | 14                                        | ---                             | ---                              | 6                                        |

Studies on early prosodic development, from the viewpoint of production and linguistically informed, are fairly recent. The acquisition of the intonational system, for example, has only been examined in a small set of languages. The results available so far show differences among languages: intonational development seems to be early in Catalan, Spanish and European Portuguese, and later in English and Dutch. In the first group of languages, babies have an adult-like inventory of pitch accents and boundary tones, with appropriate use of pitch contours, and show a development in alignment and scaling patterns, well before the beginning of the two-word stage, that is before the production of utterances with combinations of words (Snow 2006, Chen & Fikkert 2007, Prieto & Vanrell 2007, Frota & Vigário 2008). Figures 26 and 27 illustrate the appropriate and adult-like use of different pitch contours, by a 20 months old Portuguese child that begins the two-word stage at 26 months.

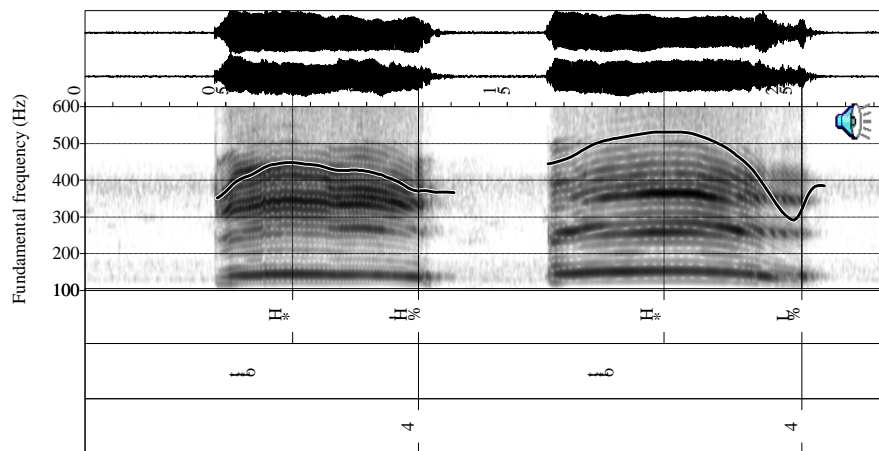


Figure 26. Production of two consecutive calling contours: chanted call followed by an insistent call.

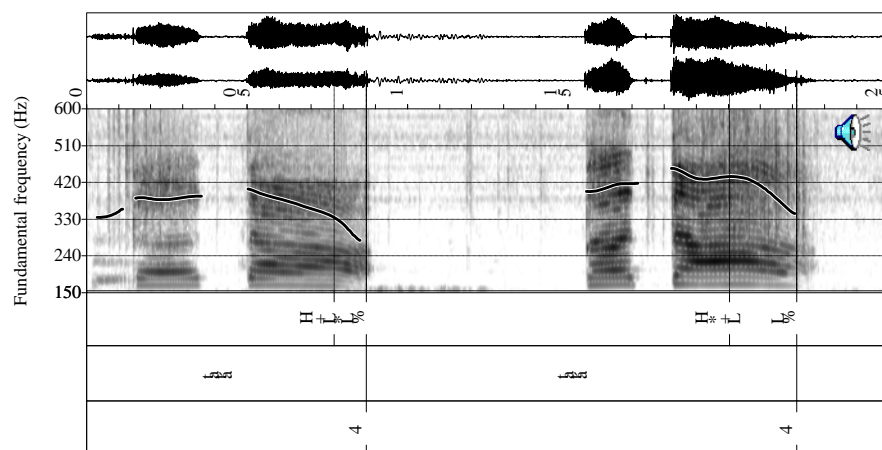


Figure 27. Sequence of answers to the adult question 'Who is this?', repeated by the adult after the first answer given by the child: neutral declarative followed by a focused declarative.

In the case of the calling contour, the child produced the chanted call first and the insistent call later, as it is pragmatically adequate, and with the right choice of boundary tones making the distinction between the two types of calling contours. In the case of the declarative contours, the child initially utters a neutral declarative, which is then replaced by a focused declarative in answer to the repetition of the same question by the adult, and making the alignment

contrast of the peak which is associated to this pragmatic difference (see section 4 of the program, especially Table 3).

The studies mentioned above show no correlation between intonational development and syntactic development. However, they point to a correlation between intonational development and lexical development, since the former appears correlated with jumps in the development of the active lexicon of the children.

Studies on the development of prosodic structure have also shown cross-linguistic differences in children early word production. The format of early words is a case in point, with languages in which the binary foot shape predominates (e.g., English, Dutch, Japanese), and languages in which monosyllabic monomoraic shapes prevail (e.g., French, Portuguese). The prosodic properties of early one-word utterances and of early multiword utterances provide cues for the prosodic status of the syllables/feet they consist of (Fikkert 1994, Odorico & Carubbi 2003, Berens & Gout 2005, Demuth & McCullough 2008). The study of such cues shows whether a given element is or not a prosodic word, or an intonational phrase, and whether two or more elements are prosodically integrated within the same phrase, or phrased separately. In other words, such a study shows the properties of the prosodic structure of the utterances produced by children, as well as the way they develop. For example, early truncation of target disyllabic words in EP, or their production with two syllables each of them uttered with a pitch accent (1PA/syll), strongly suggests an initial stage where the syllable is being treated as a prosodic word. The integration of two (or more) syllables within the same word happens later, when either truncation or production of one pitch accent per syllable almost disappear, and a sequence of syllables is uttered with a single pitch accent (disyl\_1PA) (Figure 28).

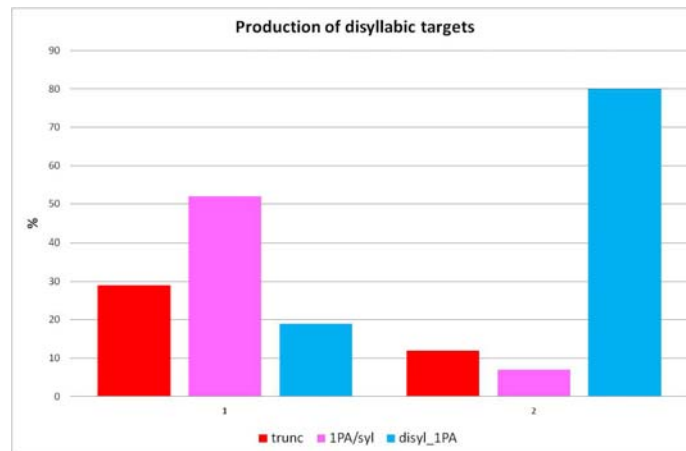


Figure 28. Strategies in the production of disyllabic targets: (1) until 1;04; (2) from 1;05 to 1;08. Data from Luma (Frota 2010).

Similarly, the absence of prosodic integration in early multiword utterances, shown by prosodic cues like pauses or reset (see section 4 of the program), reveals that these utterances are formed by sequences of one-word-phrases (Figure 29) that contrast with sequences of words phrased within the same prosodic constituent (Figure 30). Naturally, the absence/presence of prosodic integration has implications not only for the knowledge of prosodic development, but also for the knowledge of the emergence of syntax.

Given the complexity of the factors involved in the language acquisition process, after decades of research in language perception and the more recent studies on language production, the knowledge of the role of prosody in this process is still fragmentary. Many research paths remain to explore, such as the ones mentioned below as possible examples.

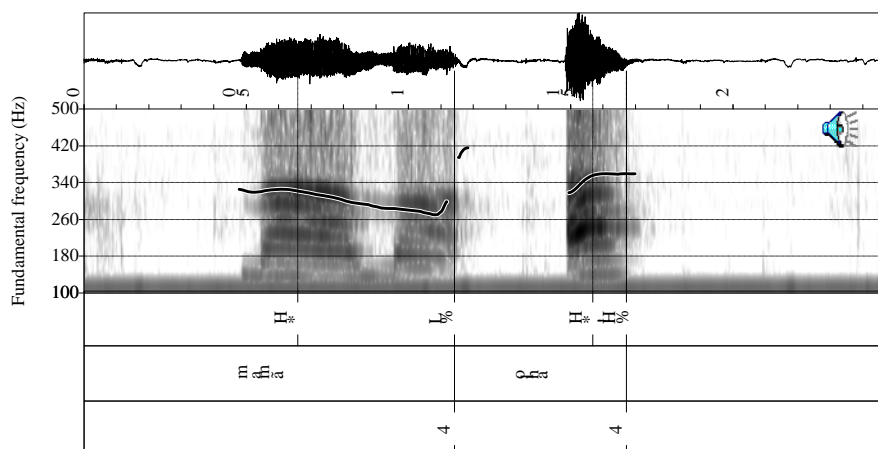


Figure 29. The utterance *Mamá olha* 'Mum look', produced with two intonational phrases (1;09).

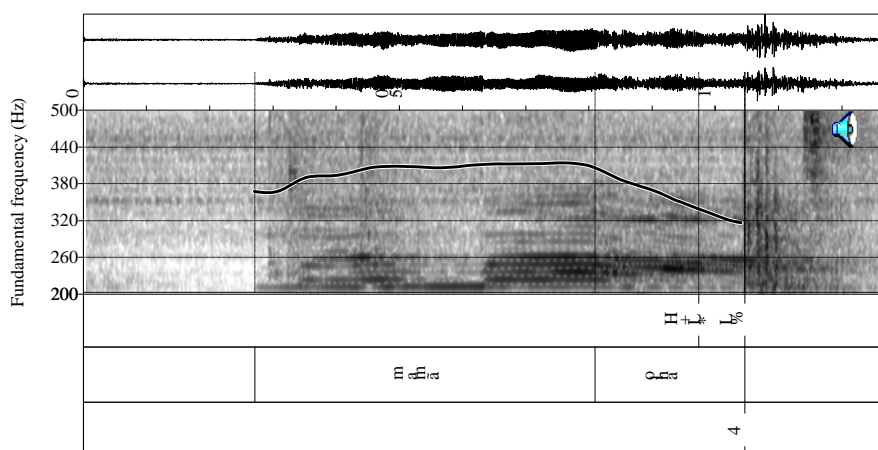


Figure 30. The utterance *Mamá olha* 'Mum look', produced with one intonational phrase (1;11).

Different rhythmic properties seem to account for different strategies in segmentation (see (30) above), and the shapes of the early words correlate with these strategies. However, the relation between the units of segmentation in perception during the first year of life and the linguistic units in early production during the second year of life remains to be determined. In the last years, increasing evidence has been put forward for the role of the properties of the input in the acquisition process. But the actual demonstration remains to be made that lexical segmentation is earlier for English learners than for French



learners due to the specific properties of the input, or that earlier intonational development in Catalan and Portuguese learners and later development in English and Dutch learners is due to input properties.

European Portuguese stands out as an interesting test case, given the specific combinations of prosodic properties that characterize the language: the mixture of syllable-timed and stress-timed properties (see section 3 of the program); the presence of intonational features similar to those found in other Romance languages (like the post-nuclear accent), together with important differences (like sparse pitch accent distribution – see section 4 of the program). Experimental research with data from EP in the domain of infant rhythmic discrimination would contribute to the understanding of which rhythmic properties are the most salient for children perception. Research on lexical segmentation by EP learners, using the same methodology of the studies made on other languages, would contribute to the discussion of the relation between rhythmic properties and units of early word segmentation. Some of these lines of research are presently being explored within the *Development of prosodic structure and intonation* project.

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